ISSUE 08
Spring 2020

Buckley Systems Technical Bulletin

D-Pace expands premises

D-Pace recently secured a $1 million USD project to develop an ion source test stand. To cope with size and timeframe of the project, D-Pace has leased 418 m^2 (4500 ft^2) of workshop space premises on the Silver King campus of Selkirk College, Nelson BC Canada. As part of the deal, Selkirk students will be able to work on non-confidential projects or undertake in-house development or experiments under supervision from D-Pace staff.

Once built, commissioned and validated, the stand will be shipped to the end-client. It is hoped to be the first of many ion source stands to be sold. The increase in turn-key, ion source sales is a direct result of the R&D efforts undertaken at the Buckley Systems based Ion Source Test Facility (ISTF) over the past six years.

D-Pace team & new facility.

Important COVID-19 coronavirus update

With the current COVID-19 pandemic, Buckley Systems is monitoring the situation and has initiated protocols to minimise the chances of staff infection. Our New Zealand based manufacturing facility is working as normal but with increased hygiene measures, PPE and appropriate social distancing. In the case of all customers who have current orders with us, we will be in contact with any updates to our manufacturing status.

With current travel restrictions, we now do not anticipate attending any of the upcoming conferences listed below but will be available to answer any questions via phone or videoconference.

Buckley Systems is well placed to weather the impact of this pandemic and we will do our utmost to provide certainty and continuity to our customers through this time.

Upcoming 2020 Conferences and Events

Buckley Systems and D-Pace were intending to have a presence at the following events pending the latest developments associated with COVID-19. The following list reflects the status of events as at April 17, 2020. Please contact Morgan Dehnel at morgan.dehnel@buckleysystems.com to discuss any upcoming projects.

- **May 10 – 15th - International Particle Accelerator Conference, (IPAC20) Caen, France,**

  11th International Particle Accelerator Conference — Cancelled

- **June 13-16th - SNMMI 2020, New Orleans, USA**

  Society of Nuclear Medicine and Molecular Imaging annual meeting. (D-Pace)

- **August 2-7th – CAARI/SNEAP, Las Vegas, USA,** — Cancelled

  26th Conference on Application of Accelerators in Research and Industry
  Combined with the 52nd Symposium of North Eastern Accelerator Personnel

- **August 24-28th – WTTC18, Whistler, Canada**

  18th Workshop on Targets and Target Chemistry (D-Pace)

- **August 31st - September 4th NIBS2020: Auckland, New Zealand** — Postponed

  7th International Symposium on Negative Beams and Ion Sources.
  Includes tour of Buckley Systems' manufacturing facility

- **September 7-11th – AMS15, Sydney, Australia** — Postponed to 2021

  15th International Conference on Accelerator Mass Spectrometry

- **September 20-24th – IIT2020, San Diego, USA**

  23rd International Conference on Ion Implantation Technology

Buckley Systems Head Office
6 Bowden Rd
Mt Wellington
Auckland1060
New Zealand
*64 9 573 2200
info@buckleysystems.com

Buckley Systems International
19 Turcotte Memorial Drive
Rowley
Massachusetts 01969
USA
*1 978 948 3403
info@buckleysystems.com

D-Pace Inc
Suite 305
625 Front Street
Nelson B.C.
Canada V1L 4B6
+1 250 352 5162
info@d-pace.com

Buckley Systems Technical Bulletin is a 6-monthly publication from Buckley Systems Ltd, distributed free to customers and selected, interested parties.

If you would like to subscribe to an email edition, please contact us at: info@buckleysystems.com

D-Pace signs licence for H^+ and H_2^+ ECR ion source

D-Pace has signed an agreement with Neutron Therapeutics to license the ECR (Electron Cyclotron Resonance) ion source technology used in their nuBeam BNCT machine. The well-proven source is powered by 2.4 GHz microwaves producing 30 mA of H^+ and over 3 mA H_2^+ continuous wave at 50 keV.

While Neutron Therapeutics is focussed purely on medical applications, the licence allows D-Pace to market the ECR source for other research and commercial applications. The agreement also allows D-Pace access to Neutron Therapeutics' ECR source test stand in Danvers, Massachusetts to test the source performance for other particles and develop the source into a fully validated, turn-key package. For example, the ECR source test stand recently confirmed that 30 mA He^+ and 0.4 mA He^{++} could be produced.

Plans are in place to research other 1^+ and 2^+ charge states. Dr Morgan Dehnel, CSIO of both D-Pace and Buckley Systems is excited by the possibilities the ion source holds. He says, "D-Pace has been solicited for high-current, H^+, D^+ and He^+ beams over the past few years so this ECR source will help us fulfil this customer need".

This issue

Bill Buckley wins New Zealand Innovator of the Year award

At the Kiwibank New Zealander of the Year awards dinner, held on February 20, 2020, Bill Buckley was presented with the New Zealand Innovator of the Year Award for 2020.

The award recognised Bill's thirty-five years at the forefront of precision electromagnet technology and his vision in developing a Boron-Neutron Capture (BNCT) system for the treatment of cancer.

Identifying the huge potential of BNCT if a cheap, reliable and medically effective dose of neutrons could be produced, Bill purchased the technology for an existing proton accelerator. The proton beam accelerator was re-engineered and uprated to produce 2.6 MeV at 30 mA and a lithium target designed to convert protons into neutrons. Extensive research and development was undertaken to ensure the water-cooled lithium target did not melt under the power of the beam.

Rather than tackle one problem at a time, Bill's determination to deliver the machine in a tight timeframe meant not only working on detailed design issues, but simultaneously developing unique, customised manufacturing equipment to streamline manufacture. Calling on the large manufacturing and technical resources at Buckley Systems in New Zealand, employing a team of experienced accelerator designers in the United States and medical professionals who had done pioneering research on and treatment with BNCT in Finland meant that the first machine, now installed in Helsinki University Hospital, will be treating patients by early 2021. What would normally have taken many years to get to trials has been achieved in a fraction of the time.

On the award, Bill says, "It's good to get the recognition for what we do here. The world is now starting to get interested in BNCT, a second machine is in production and we are fielding a lot of inquiries for more."

At 77 years old, Bill Buckley is not looking at retiring or slowing down. With a strong management structure looking after the everyday running of the business and the first BNCT machine running and performing to expectations, Bill is looking at both new opportunities and ways to be able to rapidly ramp up production when required. Large research projects can sometimes struggle to get the volume of magnets, stands and vacuum chambers they need within their desired timeframe. A deliberate strategy of Buckley Systems has been to invest in versatile, efficient machinery and to focus on being the best in the business rather than diversifying into manufacturing non-core products.

Bill has previously won, New Zealand Exporter of the Year (twice), New Zealand Excellence in Innovation Award, New Zealand Entrepreneur of the Year Award (finalist for World Entrepreneur of the Year), IPENZ Supreme Technical Award for Engineering, inducted into the New Zealand Business Hall of Fame and been awarded the New Zealand Order of Merit.

Dipole and UHV vacuum chamber

Our ability to manufacture ultra-high vacuum equipment was demonstrated recently with work for the FACET-II project at SLAC National Accelerator Laboratory in California.

A stainless steel, rectangular section, beam tube was TIG welded to custom machined, knife-edge flanges. The machined components were made on high-precision CNC equipment using sulphur free coolants compatible with high vacuum applications. During fit-up and welding, strict attention was paid to making sure the surfaces were kept free of contamination.

After manufacture, a comprehensive cleaning regime using alkali cleaners plus an ultrasonic bath was employed to remove any particulates adsorbed from the workshop atmosphere. Following ultra-high vacuum leak checks and vacuum bake-out, the chamber underwent RGA testing to ensure cleanliness was within specification.

The ability to control the manufacturing process in-house, allows us to take the special precautions required to manufacture high and ultra-high vacuum components to the highest standards.

We manufacture chambers in stainless steel and aluminium. Where possible we either machine aluminium chambers from soild or use friction-stir welding to reduce potential porosity problems.

Hamish McDonald MSc

Physicist and acrobat

Hamish has been with Buckley Systems since early 2016. He grew up in Golden Bay, one of New Zealand's most beautiful areas, located at the north-western tip of the South Island. An interest in science fiction and the purity of mathematics, led him to study at the Quantum Optics Laboratory at the University of Otago where he completed a master's degree. In early 2016, after submitting his thesis on a Friday, he started work at Buckley Systems on the following Monday morning. He has been twice to the USPAS (United States Particle Accelerator School) attending lectures on ion sources and industrial accelerators and applications, and in 2019 he attended the 7th Heavy Ion Accelerator Symposium in Canberra, Australia.

At Buckley Systems, Hamish works on magnet design using Opera™ software and Buckley Systems' extensive library of Python code to design magnets, including their coils and pole shapes, to perform beam optics simulations, and to process data from the measurements lab. Hamish enjoys the challenge of refining the pole shape to achieve the purest harmonic spectrum and has come up with some innovative designs.

Hamish's latest project is designing a "green" dipole magnet prototype, driven by permanent neodymium (NdFeB) blocks rather than a coil. A major challenge with using permanent magnets is safely assembling them without damage to the blocks or the assembler. He is investigating methods to ensure any variations in the strength of individual magnets can be compensated for, plus ensuring the field strength is not significantly altered by temperature variations.

In his spare time, Hamish, when not playing Dungeons and Dragons, enjoys the physical challenges of floor-based acrobatics, practising and refining martial arts moves in a non-combat environment.

Technology topics

Robot welder speeds up production

Buckley Systems recently invested in a robot to improve throughput in our welding department. Many of our magnets are fabricated from heavy steel plate. The amount of heat required to create a large enough weld joint plus the length of the weld means that it can be a time-consuming, hot and uncomfortable task for manual welding.

The fully articulating robotic arm can weld the perimeter of a block of steel in one pass without repositioning. This results in time savings, consistent depth of weld penetration and a neater looking weld.

Letting the robot do one of the least favourite tasks in the welding area means our experienced team can get on with more interesting and technically challenging work.

50 mm electrostatic quad triplet for D-Pace

Recent work for our partner, D-Pace, included the manufacture of an electrostatic quad triplet. Each quad has a maximum pole potential of ± 1kV, an aperture of 50 mm and pole effective lengths of 150 mm, 175 mm, 150 mm. Totally supported by standard 8" CF flanges and measuring 522.5mm overall, it can be easily incorporated into a beamline.

Confidentiality is of utmost importance

While we can get excited about some of the projects we work on and want to tell the world about our successes, customer confidentiality always comes first.

Many of our customers are competitors, but over many years, we have built and maintained strong, trust-based relationships with all of them.

Any design work we do is carefully considered to ensure none of the non-disclosure agreements we have signed are compromised in any way. Visitors to our production facilities are always escorted by staff when on our premises.

Using wire-cut EDM for high precision pole tips

With customers demanding ever higher precision for pole tip shape, alignment and position, Wire-cut EDM machining is often used as a final finishing step.

The magnet components, less the coils, are assembled and keyed together. The pole tip profiles are then EDM wire-cut to size, ensuring any tolerance stacking from assembling multiple, individual components is eliminated.

Buckley Systems runs four, Sodick LQ series wire-cut machines, renowned as being among the most technically advanced and accurate available. Linear motors eliminate potential backlash, wear and oscillation associated with traditional ball-screw and servo drives while glass-scale encoders provide an instantaneous double-check of positioning accuracy. Cutting wire sizes range from 0.30mm (0.012") diameter down to 0.15mm (0.006") for fine work. With the lower wire guide able to move independently in three axes from the upper guide, tapers and profiles can be machined easily. Maximum cut depth is 400mm and the largest machine can accommodate material up to 1600mm wide. Our experienced operators provide the essential know-how to get the very best performance out of the machines. Extensive in-house research has been done on cutting exotic materials including low-carbon steel, high permeability alloys and laminated steel used in magnets.

Real-world experience has demonstrated that wire-cutting does not induce any "cross talk" between individual laminations that may happen with mechanical methods of pole shaping such as machining or grinding.

Wire-cut pole tip segment

D-Pace and Buckley combine resources on ion source project

D-Pace recently called on Buckley Systems' physics and engineering departments to assist them with the successful tendering for the design of an innovative, turn-key ion source and spectrometer system. D-Pace's technical staff were already fully committed to other major projects when the request for tender arrived, so Buckley Systems and D-Pace CSIO, Dr Morgan Dehnel, asked the Buckley Systems Physics & Engineering Group to help. Having the work done in New Zealand had the added advantage of project manager, Dr Stephane Melanson being, able to give feedback and guidance at the end of his working day in Canada, then allowing the New Zealand team to work on solutions overnight. The project was delivered within a tight timeframe and the high quality of the work helped secure the contract to manufacture the equipment.

Another example of precision pole tips shaped by wire-cut EDM.

Power-free magnet

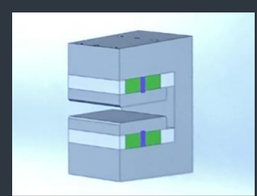
The physics department at Buckley Systems has been conducting practical research on the manufacture of rare-earth permanent, fixed field, bending magnets. Permanent magnets use no power, resulting in low environmental impact due to zero energy consumption.

While the potential advantages are great, the practicalities of manufacture and use pose some significant challenges. The magnets are difficult to handle and place in position, as strong attraction and repelling forces occur when they are brought close to iron objects or themselves.

Permanent magnets are also sensitive to temperature change. Buckley Systems' physicists are experimenting with using different magnetic materials arranged around the main magnets to help minimise any field drift over a wide temperature range.

Working closely with the engineering and design departments, a prototype magnet has been manufactured. The magnet will undergo extensive testing and used to provide data for prospective clients.

For more information contact CTO, Dr Chris Philpott.



Simulation of power-free magnet design.