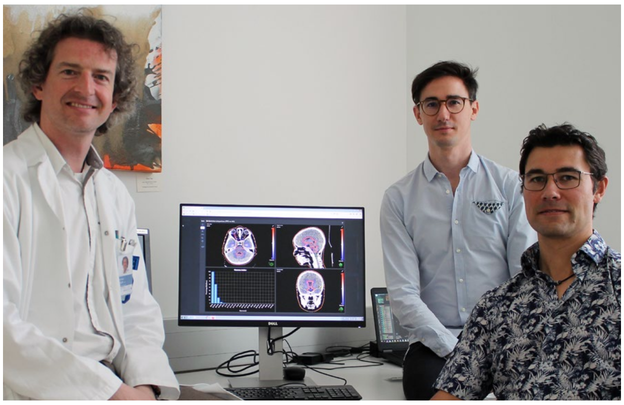
Loïc Grevillot (Beam delivery and Monte Carlo simulation group leader),
Ralf Dreindl (Medical Physicist), Markus Stock (Head of the Medical Physics Division).
MedAustron Iontherapy Center, Austria

Reimagining patient-specific QA in proton and ion therapy facilities

Medical physicists from the Austrian particle therapy centre MedAustron explain how – and why – they've put an independent QA solution at the heart of their patient treatment programme.

A ground-breaking R&D collaboration between clinical physicists at MedAustron and their industry partner IBA Dosimetry, a German supplier of independent QA solutions and services to radiation oncology clinics, is rewriting the rulebook on patient-specific QA for proton therapy. A case study in clinical translation, the partnership is focused on practical implementation of myQA iON, IBA Dosimetry's patient QA dose-verification software, yielding operational insights and technical innovations that will enable proton therapy clinics to increase their workflow efficiency while simultaneously enhancing patient safety and treatment outcomes.



Clinical translation: MedAustron is one of the flagship sites supporting clinical roll-out of IBA Dosimetry's myQA iON patient QA solution for proton therapy (shown on screen). From left to right, MedAustron medical physicists Markus Stock, Ralf Dreindl and Loïc Grevillot. (Courtesy: MedAustron)

From a commercial perspective, IBA Dosimetry is positioning myQA iON as a "game-changer" in patient QA – a software-as-a-service solution that supports the planning, delivery and management of proton therapy while ensuring interoperability with the proton treatment systems of all leading radiotherapy equipment manufacturers. As such, myQA iON gives physicists and dosimetrists the flexibility to combine Monte Carlo dose recalculation, QA based on irradiation log files, plus real-world detector measurements within a unified, automated and web-based software verification system that enables users to access their QA on-campus or remotely from any device that connects to the hospital network.

A division of labour

Over the past 18 months, MedAustron, a cancer treatment centre specializing in proton and carbon-ion therapy and related research, has emerged as one of IBA Dosimetry's flagship customer sites supporting the clinical roll-out of myQA iON. Joint activities have spanned beta testing, customer training as well as acceptance and commissioning, while subsequent physics and clinical validation by the MedAustron team enabled efficient implementation of myQA iON into the patient QA workflow. "Having the chance to collaborate with a company like IBA Dosimetry provides us with a long-term QA solution, including service and maintenance," explains Loïc Grevillot, beam delivery and Monte Carlo simulation group leader at MedAustron.

That division of labour on QA is also driven by operational necessity, given that the MedAustron clinic is still work-in-progress. The facility currently has two clinical treatment rooms with fixed proton beam lines plus one treatment room set aside for clinical and preclinical research studies. A fourth treatment room with a proton gantry will come online next year, extending patient treatment hours across the site to full capacity. As such, measurement-based patient-specific QA (with set-up and beam time) is in direct competition for beam-time needed to support the commissioning effort at MedAustron.

Game-changer: myQA iON combines Monte Carlo dose recalculation (shown here for a prostate case), QA based on irradiation log files, plus real-world detector measurements within a unified, automated and web-based software verification system. (Courtesy: MedAustron)

Beyond the commissioning phase, of course, patient-specific QA will need to be streamlined further in order to maximize the beam-time allocated for patient treatment. “That’s why MedAustron wanted to be a pioneer in Monte Carlo-based independent dose calculation,” Grevillot adds. “We’re now using myQA iON second-check calculations for a preselected subset of plans embedded in an extensive machine-based QA programme.”

So how did the MedAustron team set about integrating myQA iON into routine clinical practice? According to Grevillot’s colleague Ralf Dreindl, the first step is to identify the relevant commissioning tasks – covering beam-model aspects, CT calibration and clinical testing. “Our strategy involved moving from simple geometries in water and air phantoms to complex clinical cases in patient geometry in order to get the precise overall picture,” he explains. Other considerations include the clinical simulation settings – in terms of the trade-off between dosimetric accuracy and simulation times – as well as benchmarking the implemented gamma index for 3D dose verification. “Our clinical workflow foresees post-processing tasks that start immediately after the clinical approval of a treatment plan,” explains Dreindl. “One of these tasks is the independent dose calculation of the approved plan or beam set.”

Operationally, however, the rework of established clinical routines is always a delicate and nuanced undertaking. The MedAustron team therefore defined a two-month transition period for clinical implementation, with plan complexity being the main driver of dosimetric approval via myQA iON’s independent Monte Carlo dose calculations or the usual patient-specific QA measurements. “Since the transition period ended,” Dreindl adds, “we are now using myQA iON for all normofractionated proton treatments in the horizontal beam lines.”

Benefits realization

In-house analysis indicates significant – and immediate – efficiency gains since the MedAustron team implemented myQA iON clinically on the centre’s two horizontal proton beam lines. During the first two months of operation (starting in February 2021), Dreindl and colleagues noted an average 24% reduction in patient-specific QA measurements for single-field optimized proton beams (in which the spot positions and weights of each proton field are optimized individually, yielding uniform dose distribution over the tumour target). Multiple-field optimized beams (with highly conformal dose distributions to the target volume) are also now part of the mix for independent dose check, yielding up to a 50% reduction in patient-specific QA measurements since the beginning of April. For the near term, says Dreindl, hypofractionated treatment schedules will always be measured manually in addition to the independent dose check provided by myQA iON.

More broadly, the reduction in patient-specific QA measurements is strongly dependent on the "patient mix”. For the moment, MedAustron can only simulate horizontal proton beam lines, but there are plans to start with the vertical proton beam line in spring 2022 after commissioning is complete on the new treatment room with proton gantry. Other joint lines of enquiry with IBA Dosimetry include the implementation of irradiation log-based QA at MedAustron – to provide fraction-by-fraction monitoring and evaluation of treatment delivery accuracy – as well as the integration of the GATE-RTion/IDEAL Monte Carlo dose calculation engine (developed by MedAustron) into myQA iON to support the clinical implementation of independent dose check for carbon-ion therapy. "We cannot fully replace the patient-specific QA measurements with independent dose check," notes Dreindl, "though the integration of log-file-based QA may be an interesting route to further reduce QA measurements beyond the current 50% threshold."

The MedAustron Proton Therapy center in Wiener Neustadt, Austria.

Better together

Just 18 months after they started working together, the collaboration between MedAustron and IBA Dosimetry is going from strength to strength. "As a clinical user, it's essential for us to have a comprehensive tool like myQA iON which has undergone a certification process," notes Markus Stock, head of the medical physics division at MedAustron. "Working as part of a collaboration, we always have a hot-line to the team at IBA Dosimetry for assistance on installation, commissioning and the testing of new functionality."

Validation of a prostate treatment plan with myQA iON. Irradiation Log based patient QA using the Spot Map Analysis function.

One thing is certain: as cancer care providers seek continuous improvements in treatment efficacy, next-generation particle therapy systems will be pushed to the limits – of physics and engineering – when it comes to targeting accuracy, dose distribution accuracy and the sparing of healthy tissue. All of which translates into evolving and increasingly complex demands on patient, machine and workflow QA. "That's why it's essential for industry and clinical users to work hand-in-hand to deliver user-friendly, patient-centric QA technologies that support clinical decision-making and workflow efficiency," concludes Stock.

For more information about myQA iON for Proton Therapy - visit:
www.iba-dosimetry.com/product/myqa-ion/