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Focus collection
Quality assurance in the spotlight

May 2026

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Streamlining the radiotherapy workflow **p6**

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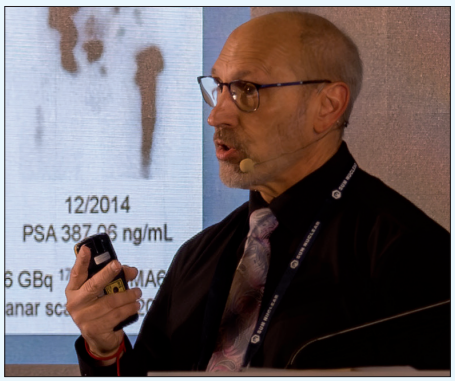

LATEST ARTICLE

Theranostics

John Sunderland from the University of Iowa presented an introduction to radiopharmaceutical therapy and theranostics. (Courtesy: Sun Nuclear)

p15

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Focus collection
Quality assurance in the spotlight

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Margaret Johns is President of RTQA at Sun Nuclear, a Mirion Medical company, leading global strategy and operations across hardware, software and services. She has held executive leadership roles including General Manager of Fluke Calibration, with experience across the medical device and healthcare technology sectors at AMETEK, Agilent Technologies and MTS Systems. She holds an MS from the University of Tennessee and a BA from the University of Memphis.

Toward a more connected approach to quality assurance

Radiation medicine is evolving quickly. As new treatment techniques take hold and care pathways become more connected, the expectations placed on quality assurance continue to grow.

Across radiation oncology, nuclear medicine and the emerging field of theranostics, one thing remains constant: confidence in each step of the patient journey depends on the strength and consistency of QA. The way that consistency is delivered, however, is shifting in response to these demands.

The articles in this collection reflect how QA is adapting in practice to meet the demands of more complex, data-rich treatment environments.

We're seeing meaningful progress in daily machine QA, where integrated platforms bring together dosimetry, imaging, and positioning into more unified workflows. At the same time, enterprise-scale systems are helping clinics centralize QA data and reduce the friction that often comes with managing it across teams and sites. These are not just efficiency gains. They give physicists and clinical teams clearer visibility into performance and greater confidence in the decisions they make every day.

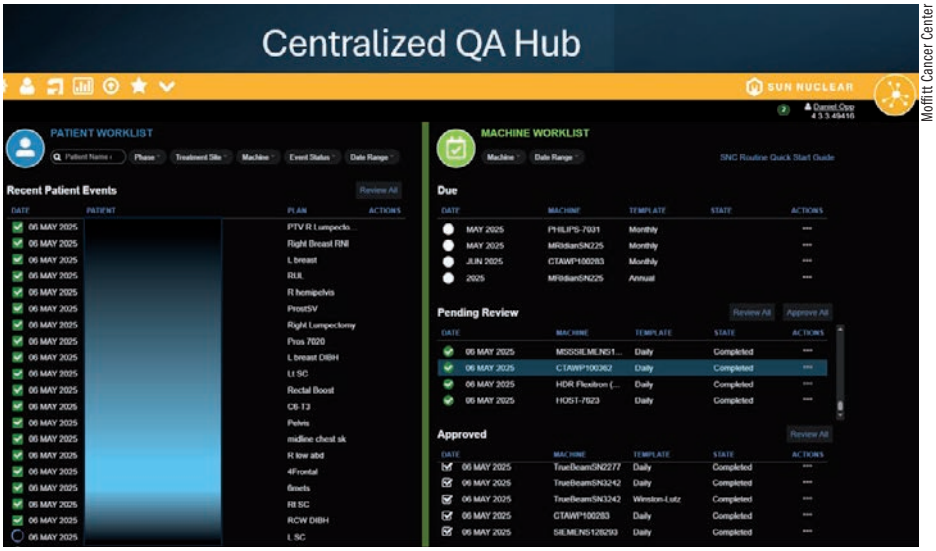
There's also a shift happening in treatment planning. Intelligent software, including AI-driven tools, is expanding what's possible. It helps clinicians develop highly personalized plans while maintaining the rigor that quality demands and that physics teams help uphold.

Taken together, these developments point to a broader move toward more connected, collaborative approaches to care. As theranostics continues to bridge imaging and therapy, that need for alignment across disciplines will only become more important.

At Sun Nuclear, we see QA as a foundation that brings these pieces together across technologies, workflows, and teams. We hope the perspectives in this collection offer useful context as you consider what comes next for your own practice.

Cancer centres streamline radiotherapy workflow with SunCHECK QA platform

Radiation oncology departments can save hundreds of QA hours each year with the SunCHECK quality management platform



Moffitt Cancer Center

SunCHECK platform The centralized hub shows the patient QA worklist on the left and the machine QA worklist on the right.

As the number of cancer cases continues to grow, radiation oncology departments are under increasing pressure to treat more and more patients. And as clinical facilities expand to manage this ongoing growth, and technology developments increase the complexity of radiotherapy delivery, there's an urgent need to optimize the treatment workflow without ramping up time or staffing requirements.

To enable this level of optimization, radiation therapy departments will require an efficient quality management system that can handle both machine and patient quality assurance (QA), works seamlessly with treatment devices from multiple vendors, and provides the time savings required to ease staff workload.

Driven by growth

A case in point is the Moffitt Cancer Center in Florida, which in 2018 shifted all of its QA to SunCHECK, a quality management platform from Sun Nuclear that combines hardware and software to streamline treatment and delivery system QA into one centralized platform. Speaking at a recent Sun Nuclear webinar, clinical physicist Daniel Opp explained that the primary driver for this switch was growth.

"In 2018, our physicians were shifting to perform a lot more SBRT [stereotactic body radiation therapy]. Our leadership had plans in motion to add online adaptive planning as well as expand with opening more radiation oncology centres," he explained.

At that time, the centre was using multiple software platforms and many different imaging phantoms to run its QA, with physicists still relying on manual measurements and qualitative visual assessments. Now, the team performs all machine QA using SunCHECK Machine and almost all patient-specific QA [PSQA] using SunCHECK Patient.

"Our QA software and data were fractured and all over the place," said Opp. "The move to SunCHECK made sense as it gave us the ability to integrate all measurements, software and databases into a one-stop shop, providing significant time savings and far cleaner record keeping."

SunCHECK also simplifies QA procedures by consolidating tests. Opp explained that back in 2018, photon tests on the centre's linacs required five setups, 12 measurements and manually entering values 22 times; SunCHECK reduced this to one setup, four measurements and no manual entries. "This alone gives you an overview of the significant time savings," he said.

Another benefit is the ability to automate tests and ensure standardization. "If you tell our large group of physicists to do a picket fence test, we'll all do it a little differently," Opp explained. "Having one system on which we're all running the same tests means that we're able to do the test in the same way across all our linacs."

Opp noted that SunCHECK displays all required information on an easy-to-read screen, with the patient QA worklist on one side and the machine QA worklist on the other. "You see a snapshot of the clinic and can figure out if there's anything you need to take care of. It's very efficient in letting you know when something needs your attention," he said.

A unified platform

Medical physicist Patricia Sansourekidou of the University of New Mexico (UNM) Comprehensive Cancer Center in Albuquerque, also implemented SunCHECK to improve the efficiency of the site's quality management programmes.

Sansourekidou initiated the switch to SunCHECK after joining UNM in 2020 as its new director of medical physics. At that time the cancer centre was treating about 1000 patients per year. But high patient numbers led to a long waiting list – with roughly three months between referral and the start of treatment – and clear need for the facility to expand.

Assessing the centre's QA procedures in 2020 revealed that the team was using a wide variety of QA software, making routine checks time consuming. Monthly linac QA, for example, required roughly 32 files and took about 14 hours to perform. In addition, Sansourekidou noted, physicists were spending hours every month adjusting the machines. "One day it was the energy that was off and then the output was off; I soon realised that, in the absence of appropriate software, we were making adjustments back and forth," she said. "More importantly, we had no way to track these trends."

Sansourekidou concluded that the centre needed an improved QA solution based

Workflow	Before SNC (hrs/vr)	Before SNC (hrs/vr)	Efficiency (hrs/vr)	Efficiency (%)
Therapy Daily QA	594	238	356	40.0%
Physics Monthly QA	504	180	324	35.7%
Physics Annual QA	180	120	60	66.7%
Patient Specific IMRT QA (70%)	231	58	173	25.3%
Patient Specific InVivo (10%)	50	8	42	16.7%

Patricia Sansourekidou

Efficiency savings QA times before and after implementing SunCHECK at the UNM Comprehensive Cancer Center.

on one unified platform. "So we went on a physics hunt," she said. "We met with every vendor out there and Sun Nuclear won the request for proposal. So we implemented SunCHECK Machine and SunCHECK Patient."

Switching to SunCHECK reduced monthly QA to just 4–5 hours per linac. "We're saving about nine hours per linac per month; that's 324 hours per year when we could be doing something else for our patients," said Sansourekidou. Importantly, the new software enables the team to visualize trends and assess whether a genuine problem is present.

For daily QA, which previously required numerous spreadsheets and systems, SunCHECK's daily QA template provides time savings of about 60%. "At six in the morning, that's important," Sansourekidou pointed out. Annual QA saw roughly 33% time savings, while for the 70% of patients requiring PSQA, time savings were about 25%.

Another "unexpected side effect" of deploying SunCHECK, said Sansourekidou, is that the IT department was happy to maintain one platform. "Every time we have a new physicist, it's much easier for our IT department to set them up. That has been a huge benefit for us," she said. "Additionally, our service engineers are happy because we are not spending hours of their time adjusting the machine back and forth."

"Overall, I thought there were great improvements that really helped us justify the initial investment – not just monetary, but also time investment from our physics team," she said.

Phantom-free QA

For Opp, one of the biggest features enabled by SunCHECK was the move to phantom-free PSQA, which saves a lot of time and eliminates errors that can be inherent to phantom-based QA. In the last year, the Moffitt team also switched to using DoseCHECK – SunCHECK's secondary 3D dose calculation algorithm – as the foundation of its quality checks. Alongside, a RayStation script checks plan deliverability to ensure that no problems arise once the patient is on the table.

"We don't do our pre-treatment QA anymore. We rely on those two to get confidence into the final work and then we run our logs off the first patient fraction," Opp explained. "We have a large physics group and there was natural apprehension, but everybody got on board and agreed that this was a shift we needed to make. We leveraged DoseCHECK to create a better QA system for ourselves."

Since 2018, both patient workload and staff numbers at the Moffitt Cancer Center have doubled. By the end of 2025, it will also have almost doubled its number of treatment units. The centre has over 100 SunCHECK users – including therapists, dosimetrists and physicists – and Opp emphasized that the system is robust enough to handle all these users doing different tasks at different times without any issues.

As patient numbers increase, the time savings conferred by SunCHECK help reduce staff workload and improve quality-of-life for users. The centre currently performs about 100 PSQA procedures per week, which would have taken about 37 hours using previous QA processes – a workload that Opp notes would not be managed well. SunCHECK reduced the weekly average to around seven hours.

Similarly, linac QA previously required two or three late nights per month (or one full day on the weekend). "After the switch to SunCHECK, everybody's pretty much able to get it done in one late night per month," said Opp. He added that the Moffitt Cancer Center's continuing growth has required the onboarding of many new physicists – and that it's significantly easier to train these new staff with all of the QA software in one centralized platform.

Enabling accreditation

Finally, accreditation is essential for radiation oncology departments to demonstrate the ability to deliver safe, high-quality care. The UNM Comprehensive Cancer Centre's previous American College of Radiology (ACR) accreditation had expired before Sansourekidou's arrival, and she was keen to rectify this situation. And in March 2024 the centre achieved ASTRO's APEx accreditation.

"SunCHECK helped with that," she said. "It wasn't the only reason, there were other things that we had to improve, but we did come across as having a strong physics programme."

Achieving accreditation also helps justify the purchase of a totally new QA platform, Sansourekidou explained. "The most important thing to explain to your administration is that if we don't do things the way that our regulatory bodies advise, then not only will we lose our accreditation, but we will fall behind," she said.

Sansourekidou emphasized that the efficiency gains conferred by SunCHECK were invaluable for the physics team, particularly for out-of-hours working. "We saw huge time savings for both monthly and daily QA," she said. "It is a large investment, but improving efficiency through investment in software will really help the department in the long term."

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This article was written by *Physics World* on behalf of Sun Nuclear. Read more on *physicsworld.com*.

Todd McNutt: how an AI software solution enables creation of the best possible radiation treatment plans

Sun Nuclear

Introducing AI into the clinic Todd McNutt discusses the advantages of predictive planning using Plan AI.

Medical physicist Todd McNutt explains how Plan AI, an artificial intelligence-powered plan quality software solution, uses data mining to streamline and improve radiotherapy planning for cancer treatments.

Todd McNutt is a radiation oncology physicist at Johns Hopkins University in the US and the co-founder of Oncospace, where he led the development of an artificial intelligence (AI)-powered tool that simultaneously accelerates radiation planning and elevates plan quality and consistency. The software, now rebranded as Plan AI and available from US manufacturer Sun Nuclear, draws upon data from thousands of previous radiotherapy treatments to predict the lowest possible dose to healthy tissues for each new patient. Treatment planners then use this information to define goals that streamline and automate the creation of a best achievable plan.

Physics World's Tami Freeman spoke with McNutt about the evolution of Oncospace and the benefits that Plan AI brings to radiotherapy patients and cancer treatment centres.

Can you describe how the Oncospace poject began?

Back in 2007, several groups were discussing how we could better use clinical data for discovery and knowledge generation. I had several meetings with folks at Johns Hopkins, including Alex Szalay who helped develop the Sloan Digital Sky Survey. He built a large database of galaxies and stars and it became a huge research platform for both amateur and professional astronomers.

From that discussion, and other initiatives, we looked at moving towards structured data collection for patients in the clinical environment. By marrying these data with radiation treatment plans we could study how dose distributions across the anatomy affect patient outcomes. And we took that opportunity to build a database for radiotherapy.

What inspired the transition from academic research to founding the company Oncospace Inc in 2019?

After populating the database with data from many patients, we could examine which anatomic features impact our ability to generate a plan that minimizes radiation dose to normal tissues while treating target volumes as best as possible. We came up with a feature set that characterized the relationships between normal anatomy and targets, as well as target complexity.

This early work allowed us to predict expected doses from these shape-relationship features, and it worked well. At that point, we knew we could tap into this database and generate a prediction that could help create treatment plans for new patients. We thought of this as personalized medicine: for the first time, we could see the level of treatment plan quality that we could achieve for a specific patient.

I thought that this was useful commercially and that we should get it out to other

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Left: Plan AI software Comparing dose–volume histogram prediction bands with clinical goals (arrows) provides users with valuable feedback on what can be
Right: Clinical plan The screen shows a review of the results that the treatment planning system achieved, with dose–volume histograms shown by the solid

clinics. Praveen Sinha, who I'd known from my previous work at Philips and now leads Sun Nuclear's software business line, asked if I wanted to create a startup. The timing was right for both of us and I had a team here ready to go, so we went ahead and did it. With his knowledge of startups and my knowledge of what we wanted to achieve, we had perfect timing and a perfect group to work with.

Plan AI enables both predictive planning and peer review, how do these functions work?

The idea behind predictive planning is that, for a given patient, I can predict the expected dose that I should be able to achieve for them.

Treatment planning involves specifying dosimetric objectives to the planning system and asking it to optimize radiation delivery to meet these. But nobody really knows what the right objectives even are – it is just a trial-and-error process. Plan AI's prediction provides a rational set of objectives for plan optimization, allowing the planning system's algorithm to move towards a good solution and making treatment planning an easier problem to solve.

Peer review involves a peer physician looking at every treatment plan to evaluate it for quality and safety. But again, people don't really know the level of quality you can generate, it depends on the patient's anatomy. Providing a predicted dose with clinical dose goals enables a rapid review to see whether it is a high-quality plan or not.

In the past we looked at simple things like whether a contour is missing slices or contains discontinuities and Plan AI checks for this, but you can do far more with AI. For example, you could look at all the contoured rectums in the system and predict if your contour goes too far into the sigmoid colon, then it may be mis-contoured. We have research software that can flag such potential anomalies so they don't get overlooked.

The Plan AI models are developed using Oncospace's database of previous treatments; can you describe this data lake?

When we first started, we developed a large SQL database containing all the shape-relationship features and dosimetry features. The SQL language is ideal for being able to query and sift through the data, but when the company was formed, we recognized that there was some age to that technology.

So for the Plan AI data lake, we extracted all the different shape-relationship and shape-complexity features and put them into a Parquet database in the cloud. This made the data lake much more amenable to applying machine learning algorithms to it. The SQL data lake at Johns Hopkins is maintained separately and primarily used to investigate toxicity predictions and spatial dose patterns. But for Plan AI, the models are fixed and streamlined for the specific task of dose prediction.

What does the model training process entail?

One of the first tasks was to curate the data, using the AAPM's standardized structure-naming model. Our data scientist Julie Shade wrote some tools for automatic name mapping and target identification; that helped us process much larger amounts of data for the model.

Once we had all the shape-relationship and shape-complexity features and all the doses, we trained the models by anatomical region. We have FDA-approved models for the male and female pelvis, thorax, abdomen and head-and-neck. For each of these, we predict the doses for every organ-at-risk. Then we used a five-fold validation model to make sure that the predictions were good on an internal data set.

We also performed external validation at institutions including Johns Hopkins and Montefiore hospitals. We created predicted plans from recent treatment plans that had been evaluated by physicians. For almost all cases, both plan quality and plan efficiency were improved with Plan AI.

One aspect of this training is that whenever we drive optimization via predictive planning we want to push towards the best achievable dose. Regular machine learning predicts an expected, or average, dose across all patients. But you never want to drive a treatment plan towards the average dose, because then every plan you generate will be happy being average. Our model predicts both the average and the best achievable dose, and drives plan optimization towards the best achievable.

When implementing new technology in the clinic, it's important to fit into the existing treatment workflow. How clinic-ready are these AI tools?

Radiation therapy is protocol-driven: we know what technique we're going to use to treat and what our clinical dose goals are for different structures. What we don't know is the patient-specific part of that. So for each anatomical region, we built models out of a wide range of treatment protocols, with many different types of patients, to ensure that the same prediction model works for

any protocol. This means a user can use any protocol for treatment and the predictions will work, they don't have to retrain anything. It's ready to go out of the box, there's a library of protocols to start with, and you can change protocols as you need for your own clinic.

The other part of being clinic-ready is aligning with the way that planning is currently performed, which is using dose–volume histograms. Treatment plans are optimized by manipulating these dose objectives, and that's exactly what we predict. So users aren't changing the whole paradigm of how planners operate. They still use their treatment planning system (TPS) – we just put the objectives in there. Basically, a TPS script sends the patient's CT and contours to the cloud, where Plan AI makes the predictions. The TPS then pulls back in the objectives built from the models, based on this specific patient's anatomy. The TPS runs the optimization and, as a last step, can send the plan back to Plan AI to check that it fits within the best achievable predictions.

Did you encounter any challenges bringing AI into a clinical setting?

Interestingly, the challenges aren't technical, they are more human related. One of the more systemic challenges is data security when using medical data for training. A nice thing about our system is that the features we generate from treatment plans are just mathematical shape-relationship features and don't involve a lot of identifiable information.

AI has been used in radiation therapy for image contouring and auto-segmentation, and early efforts were not so good. So, there's always a good, healthy scepticism. But once you show people that it works and works well, this can be overcome. I have seen some people worried about job security and AI taking over. We are medical professionals designing a treatment plan to care for a patient and there's a lot of pride and art in that – if you automate that, it takes away some of this pride and art.

I tell people that if we automate the easier things, then they can spend their quality time on the more difficult and challenging cases, because that's where their talent might be needed more.

Do you have any advice for clinics looking to adopt AI-driven planning?

Introduce it as an assistant, not as a solution. You want people that already know what they're doing to be able to use their knowledge more efficiently. We want to make their jobs easier and show them that it also improves quality.

We can provide this predictive planning tool to clinics around the world. Now we just have to get everybody using it

With dosimetrists, for example, they create a plan and work hard getting the dose down – and then the physician looks at it and suggests that they can do better. Predictive planning gives them confidence that they are right and takes the uncertainty out of the physician review process. And once you've gained that level of confidence, you can start using it for adaptive planning or other technologies.

Where do you see predictive modelling and AI in oncology in five years from now?

Right now, there's been a lot of data collected, but we want that data to advance and learn. Having multiple centres adding to this pool of knowledge and being able to continually update those models from new, broader data sets could be of huge value.

In terms of patient outcomes, we've done a lot of the work looking at how the spatial pattern of dose impacts toxicity and outcomes. This is part of the research being performed at Johns Hopkins and still in discovery mode. But down the road, some of these predictions of normal tissue outcomes could be fed into the planning process to help reduce toxicity at the patient level.

Finally, what's been the most rewarding part of this journey for you?

During my prior experience building treatment planning systems, the biggest problem was always that nobody knew what the objective was. Nobody knew how to tell the system: "this is the dose I expect to receive, now optimize to get it for me", because you didn't know what you could do. For any given patient, you could ask for too much or too little. Now, for the first time, I argue that we actually know what our objective is in our treatment planning.

This levels the playing field between different environments, different countries, or even different dosimetrists with different levels of experience. The Plan AI tool brings all this to a consistent state and enables high quality, efficient planning everywhere. We can provide this predictive planning tool to clinics around the world. Now we just have to get everybody using it.

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AI-based tool improves the quality of radiation therapy plans for cancer

To find out more about Plan AI, listen to the full interview with Todd McNutt in this episode of the *Physics World Weekly* podcast

In a conversation with *Physics World*'s Tami Freeman, McNutt explains how an artificial intelligence-based tool called Plan AI can help improve the quality of radiation therapy plans for cancer treatments.

As well as discussing the benefits that Plan AI brings to radiotherapy patients and cancer treatment centres, they examine its evolution from an idea developed by an academic collaboration to a clinical product offered today by Sun Nuclear, a US manufacturer of radiation equipment and software.

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Daily QA 4 Pro redefines machine quality assurance for next-generation radiotherapy

Integrating all dosimetry and positioning verification into a single device, Daily QA 4 Pro enables comprehensive machine QA in a single setup and session

Sun Nuclear

Quality and patient safety in radiotherapy Attendees at the QADS15 event shared best practice strategies and clinical insights with colleagues practicing worldwide.

For radiotherapy centres, daily quality assurance (QA) provides the final safety check before each day of patient treatments – ensuring that all linear accelerators (linacs) deliver radiation safely, accurately and as expected.

But as radiotherapy technologies evolve, the required QA procedures become increasingly complex, with verification tests often performed in isolation using multiple phantom set-ups. New treatment techniques – such as surface-guided radiotherapy (SGRT), which is more widely used now than ever – also introduce new QA requirements. And the ongoing adoption of adaptive radiotherapy, where measurement-based pre-treatment QA is not possible, increases the emphasis on machine QA, in which daily QA plays a key role.

What's needed is a comprehensive QA approach that incorporates the dosimetry, imaging and positioning checks required for all radiotherapy modalities. Addressing this challenge, US manufacturer Sun Nuclear has launched Daily QA 4 Pro, a new device that simplifies daily machine QA by combining dosimetry and positioning verification via imaging into a single indexed, imageable platform.

"The main motivation for launching the Daily QA 4 Pro was to create a product that not only met the current needs of clinicians, but also future needs, based on our vision of the radiotherapy QA field," explains Rajiv Lotey, technical product manager for the Daily QA 4 Pro.

The next-generation platform builds on the company's Daily QA 3 beam quality analysis product, which was introduced more than a decade ago and is now standard in many radiotherapy departments. "The biggest difference between the Daily QA 4 Pro over the Daily QA 3 is the end-to-end QA functionality – representing the patient workflow – achieved by integrating a 3D high-resolution array, fiducials, an SGRT-compatible surface, an imageable architecture, and the ability to correlate all imaging and mechanical isocentres together onto one device," says Lotey.

Enabling new modalities, expanding clinical applications

David Barbee, Director of Technology and Innovation in Radiation Oncology at NYU

Sun Nuclear

Early adopter David Barbee, Director of Technology and Innovation in Radiation Oncology at NYU Langone Health and one of the first users of Daily QA 4 Pro, describes his experiences of the next-generation QA platform.

Langone Health, was one of the first to adopt this technology. Speaking at the recent QA & Dosimetry Symposium (QADS) hosted by Sun Nuclear, he described his early experiences of using the next-generation Daily QA 4 Pro.

"The first thing I wanted to do was evaluate surface-guided radiation therapy, because we don't currently do this during daily QA," Barbee explained.

To perform this test, the team defined a region-of-interest in the hospital's VisionRT SGRT system that covered the entire surface and edges of the Daily QA 4 Pro and tested it over the full range of couch motion. The maximum translation range that it could detect was about ±4.5 cm in the lateral (side to side) and longitudinal (along the couch length) directions, and +13 to –17 cm vertically.

"For pitch and roll, we tested the 3°/3 mm limits and 90° couch rotations, and it observed them perfectly," he added. "This is the first time we've ever run this test and compared our SGRT system to our image guidance system," he noted. "This is very, very helpful."

For dosimetry, Barbee noted that many parameters are carried over from the Daily QA 3 – including the output profile constancy, the field size and shift, and the flatness and symmetry – but added that the Daily QA 4 Pro can measure at a much wider range, anywhere from 2 to 20 cm square fields. "There are also new metrics, such as the penumbra, beam shape constancy for FFF [flattening filter-free] fields, the beam centre and the dose-per-pulse," he explained. "And there's a new dose output correction factor for when you need to move this device to a different unit."

Barbee and colleagues performed a range of dosimetry assessments using the Daily QA 4 Pro, measuring 30 sessions on six linacs using both jaw- and multi-leaf collimator (MLC)-defined field sizes. They found that the output factors were consistent down to about 7 mm, after which the MLC gave slightly higher output factors, while the largest beam profile differences were seen in flatness and symmetry for very small fields.

Integrating Winston–Lutz

The Daily QA 4 Pro incorporates active measurement Winston-Lutz tests – a standard procedure for evaluating isocentre accuracy – using the system's onboard 3D detector array to directly measure the radiation isocentre. The NYU Langone team used the Daily QA 4 Pro to quantitatively assess the mechanical isocentres and their response to gantry, collimator and couch motion for six linacs, again using both jaw- and MLC-defined fields.

Barbee noted that the system runs the gantry and collimator checks automatically. "You can basically hit play on SunCHECK and then you don't touch anything again until you get to the couch, which you have to move from the console," he explained.

To test the accuracy of the results, Barbee compared them with two years' worth of Machine Performance Check (MPC) and traditional Winston-Lutz measurements of all of the centre's linacs. Daily QA 4 Pro measurements agreed well with previous isocentre results across all machines tested. "It's a little bit early to say, but it looks commensurate, there are no concerns," he noted.

The team also ran active imaging Winston-Lutz tests, which evaluate system geometry by analysing the position of a known target in images acquired using the linac's imaging panels. The Daily QA 4 Pro device detects the image fiducials (tungsten carbide BBs) and compares their positions to expected values for each gantry angle. These tests allow users to assess factors such as device positioning, gantry angle accuracy and overall alignment.

"This is all summarized into a report showing the maximum error in any one of those parameters across all gantry angles," explained Barbee. "It will tell you which gantry angle was the worst and what the value there was."

Used together, the two Winston-Lutz methods combine direct radiation measurement with imaging-based verification to provide a more complete understanding of system health and to help identify, quantify and correct any errors.

Efficiency analysis

Barbee notes that while the Daily QA 4 Pro generates a comprehensive set of dosimetry and positioning verification data, at first glance, it looks like a lot more work. An efficiency analysis, however, proved the opposite – demonstrating significant gains in workflow efficiency.

Currently, Daily QA 3 and IGRT tasks take about 16 min to perform. "Daily QA 4 Pro cuts about five minutes off that time, because you're not going in and out of the room and doing multiple setups," he explained. "Adding Winston-Lutz currently doubles the time to over half an hour. But with Daily QA 4 Pro, you only add five minutes. And it's a simple setup that your therapist can run as part of their morning QA."

"The Daily QA 4 Pro integrates image-guided radiotherapy, SGRT, beam dosimetry and Winston-Lutz verification into a single device, enabling comprehensive daily QA in a single setup and session," Barbee concluded. "This provides an independent, interpretable alternative to vendor black-box QA systems, with comparable isocentre and imager tests, and superior beam quality constancy tests. It really can consolidate a lot of phantoms that you might not need anymore."

A look inside the device

The Daily QA 4 Pro measures 30 x 50 x 6 cm, weighs 6.2 kg and sits on a 4.1 kg six degrees-of-freedom base. It incorporates four ion chambers that measure field sizes down to 5 x 5 cm, as well as 249 diodes spaced at high resolution in the x– and y-directions, the diagonals and along both sides. There are also eight 3 mm tungsten carbide BBs positioned off-axis, factory-calibrated to enable micron-level corrections.

The Daily QA 4 Pro.

Externally, the device incorporates scribed laser alignment marks with 2 mm tolerance on its sides and surfaces, plus a crosshair for collimator alignment. There are also field size markings for 5 x 5, 10 x 10 and 20 x 20 cm fields, as well as eight symmetric reliefs designed specifically for SGRT.

The Daily QA 4 software is designed to integrate into the SunCHECK environment and can be controlled using either SunCHECK Local via a standalone laptop or (starting in version 6.0) the SunCHECK Server.

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Theranostics: building the bridge between nuclear medicine and radiation oncology

With theranostics set to play an increasing role in cancer treatments, Mirion Medical products empower medical physicists as they introduce radiopharmaceutical techniques into the clinic

In the ongoing quest to improve cancer treatments, the radiation oncology community is looking to add to its armoury of radiation-based treatments. In particular, radiopharmaceutical therapy (RPT) – also known as molecular radiotherapy (MRT) – and the emerging sub-field of theranostics are set to play an expanded role as radiation medicine shifts towards a more integrated, multidisciplinary approach.

RPT is an evolving modality that uses a tumour-targeting molecule attached to a therapeutic radioisotope to deliver radiation directly to tumour cells. Theranostics takes this approach a step further, pairing the therapeutic radioisotope with a diagnostic analogue to image the disease before therapy and predict how the radioactive drug will be taken up by a specific patient.

"Interest in theranostics has really exploded since the clinical approvals of two radioactive drugs that are being used right now to treat patients," explained Jeff Kapatoes, vice-president of regulatory, physics and product at Mirion Medical, at the recent QA & Dosimetry Symposium (QADS) hosted by Sun Nuclear.

The two approved drugs – Lutathera and Pluvicto – are approved for treating neuroendocrine tumours and certain prostate cancers, respectively, currently for later-stage disease but with multiple clinical trials ongoing to expand their remit to early-stage disease. "There are also active trials that treat other disease sites, such as lymphoma, breast and lung," Kapatoes noted. Alongside, some 70 companies are developing their own therapeutic radiopharmaceuticals, with nine candidates now in phase-three trials and closing in on approval.

But despite its vast potential, theranostics is still in the early stages of widespread clinical adoption. While external-beam radiotherapy benefits from established treatment and quality assurance methodologies, this is simply not the case for theranostics. And as demand continues to grow, it's vital that the full theranostic workflow is standardized – from radioisotope production through to final delivery to the patient.

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Standardizing clinical RPT John Sunderland from the University of Iowa presented an introduction to radiopharmaceutical therapy and theranostics, and described how the Precision Dosimetry Imaging Biomarker project aims to standardize calibration and dosimetry procedures.

Mirion Medical can support this integration of theranostics into radiation oncology, offering a broad portfolio of products designed for the entire theranostics lifecycle. The transition will also rely heavily on the contribution of medical physicists, who are uniquely positioned to implement theranostics programmes within their institutions.

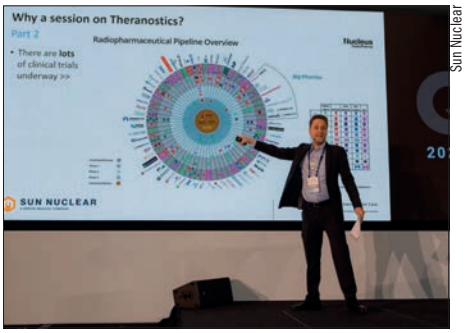
Theranostics today

Speaking at the QADS event, John Sunderland from the University of Iowa explained the current situation. "The reality is, in external-beam radiotherapy, there are methods to ensure that the beam reaches the right place and the energy deposited is what you think. In RPT, you don't control where the dose goes, biology and biochemistry do."

He described a typical theranostic prostate cancer treatment, which begins with a PET/CT scan to visualize how a diagnostic radioisotope binds to the patient's prostate cancer cells. Candidate patients are then injected with a therapeutic radioisotope comprising the same cancer-targeting molecule labelled with the beta emitter lutetium-177 (^{177}Lu), which delivers highly localized radiation dose to the tumours. Importantly, this drug can also be imaged, using SPECT/CT to track its delivery.

Serial imaging enables treatment to be tailored to a patient's response. Sunderland discussed one patient who had almost complete response after three treatments with Pluvicto (which is delivered in up to six cycles of 200 mCi). "There's no reason to keep giving radiation dose to this patient, which might result in adverse events, we may as well stop," he explained.

More typically, a patient will exhibit stable disease or a modest response – likely because not enough dose was delivered to the tumour. Simply increasing the amount of injected activity, however, risks increasing the dose to non-target organs such as kid-



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Emerging technologies Jeff Kapatoes of Mirion Medical introduced the session on theranostics at the QA & Dosimetry Symposium.

neys or bone marrow. "Instead, we're trying to move to dosimetry-modulated RPT where you modulate the amount of injected activity based upon the dosimetry in that first cycle," Sunderland explained. "Then you can optimize the efficacy while maintaining critical organ toxicity levels to below where they might have adverse effects."

Such dosimetry modulation requires three things: accurate measurement of the injected activity using a radionuclide calibrator; quantitative SPECT mapping of the absorbed radiation dose; and uniform software tools. But challenges remain, due to a lack of standardization at all three stages.

"Even expert physicists making the same dosimetry measurements with the same image data could vary by 20 to 30%, just because of the methodology they choose," said Sunderland. "We have to standardize. We're not where the external-beam people are, we're all doing it differently because it's so new."

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Challenging to address John Sunderland detailed the workflow for dosimetry-modulated radiopharmaceutical therapy.

The PDIB project

The Precision Dosimetry Imaging Biomarker (PDIB) project hopes to remedy this situation via three parallel projects: establishing a network of secondary standards calibration laboratories (SSCLs); standardization of SPECT/CT scanner calibration procedures; and standardization of dosimetry calculation workflows. "Only if we can do that are we actually going to be able to define our radiation dose-effect curves, as the external-beam field has been doing for years," said Sunderland.

The first project aims to enable accurate measurement of the injected dose. To achieve this, four SSCLs – at BC Cancer, the University of Iowa, the University of Alabama Birmingham and the Belgian Nuclear Research Centre – will work with the national metrology labs NIST and NPL to support clinical trials worldwide. Using high-purity germanium detectors, the labs will perform absolute activity measurements of the six most commonly used radionuclides (^{177}Lu, ^{131}I, ^{225}Ac, ^{111}In, ^{203}Pb and ^{212}Pb). These samples can then be used by radiopharmacies and imaging/therapy sites to adjust their own dose calibrators to the SSCL measurements, targeting an overall activity uncertainty of less than 3%.

The second project, designed to harmonize quantitative calibration of SPECT/CT for therapeutic radionuclides, involves 12 imaging sites across the US, Europe and Australia. "There's no standard way to calibrate right now and there's no way to validate the calibration," said Sunderland. The plan is to calibrate seven common quantitative SPECT/CT scanner models, using three different phantoms and the six radionuclides, using SSCL-supplied samples to ensure accurate activities.

The final project addresses the dosimetry calculations. Led by five international experts (two in North America, two in Europe and one in Australia), the project will examine ^{177}Lu dosimetry for kidneys, bone marrow and tumours using 20 curated ^{177}Lu-DOTATOC datasets. The teams will use five cases to develop standard operating procedures, then test these procedures on the other 15 cases, using five different dosimetry software packages, to investigate inter-user dosimetry variability.

"Radiopharmaceutical therapy is a big deal," Sunderland emphasized. "The market for nuclear medicine is growing exponentially; it's going to be double that of external-beam radiotherapy by 2030. And there are not nearly enough nuclear medicine physicists to do this work."

In the US, RPT is a shared domain between radiation oncology and nuclear medicine, with active discussion around which department should be handling radiation for therapeutic versus purely diagnostic purposes. In Europe, meanwhile, theranostics generally sits solely within the remit of nuclear medicine.

"We need to recruit the external-beam physicists into the fold," said Sunderland. "From a dosimetry and physics standpoint, there's a lot of overlap here and a lot of expertise."

Supporting the theranostics workflow

This blurring of traditional boundaries between nuclear medicine and radiation oncology creates both opportunities and complexities. With a comprehensive portfolio of products that span both domains, Mirion Medical aims to ease this convergence of disciplines and support the physicists navigating this transition.

Designed to standardize and streamline the full theranostics workflow, ec² Software enables radioisotope manufacturers, radiopharmacies and clinical facilities to provide traceability and support precision, safety and regulatory adherence.

"Products from ec² Software enhance precision through accurate dose tracking and documentation across the radiopharmaceutical lifecycle, improve safety by reducing manual steps, and support regulatory compliance with auditable records," Kapatoes explained. "Overall, ec² Software helps health systems move from fragmented processes to consistent, scalable operations."

Meanwhile, Mirion's broader Radiopharma offering supports the physical and operational infrastructure required for safe and accurate delivery of theranostic procedures. This includes dose calibrators, SPECT calibration phantoms and shielding systems from Capintec, all of which will be key enablers for the introduction of dosimetry-modulated RPT.

"While ec² provides the workflow, traceability and compliance layer, Mirion's hardware and monitoring solutions address the measurement, protection and safety environment in which those workflows operate," said Kapatoes. "Together, they create an integrated approach, linking what's happening operationally with what's happening physically. This alignment helps health systems standardize processes, reduce variability and maintain compliance as programmes scale."

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