

Bye-bye false alarms: How Monte Carlo dose calculations make patient-specific QA more efficient

In everyday clinical practice, medical physics teams face a central challenge when verifying radiotherapy treatment plans: patient-specific quality assurance (PSQA) requires the highest level of accuracy, yet it also consumes valuable resources. Independent secondary dose calculations (ISDC) offer a clear advantage over traditional phantom-based measurements: they run automatically in the background and provide fast, precise results. The choice of algorithm used for independent dose calculations therefore has a major impact on how well patient safety and workflow efficiency can be combined.

A 2025 study by [L. Hoffmann et al.\[1\]](#), published in the *Journal of Applied Clinical Medical Physics*, compared the Monte Carlo algorithm SciMoCa (as implemented in VERIQA RT MonteCarlo 3D) with the analytical convolution-superposition algorithm used in Mobius3D. The results illustrate how strongly the choice of algorithm influences daily clinical practice.

Why the Choice of Algorithm Matters

The purpose of PSQA is to detect errors and provide insight into their origin. Pre-treatment dose verification can be carried out in accordance with DIN 6875-3 or AAPM TG-218/219 either by measurements (e.g. using a phantom or EPID) or by secondary dose calculations. These two verification methods differ significantly in terms of accuracy and workload.

Dose calculations allow automated plan verification and mainly require server and computing

resources rather than staff time. Most treatment plans that are clinically uncritical and pass the secondary dose calculation do not require any additional effort from the medical physics team.

Acceptance criteria typically include Gamma Pass Rate (GPR) and dose difference. However, these metrics are only meaningful when tight tolerance limits (action levels) are applied. Problems arise when the algorithm used for secondary dose calculation has a high variance: greater variance leads to more plans being marked as out-of-tolerance, resulting in more false alarms that must be reviewed manually.

In such cases, clinics need to determine whether to maintain strict acceptance criteria and take on the additional review workload, or to relax the tolerances to reduce workload, operating with less conservative safety margins. A precise algorithm, by contrast, enables both — tight tolerances and reliable PSQA with less overall effort.

What The Study Shows

Hoffmann et al. analysed 100 patient plans across 20 clinical cases, all planned with Acuros XB. The plans were recalculated using both the analytical algorithm in Mobius3D and the Monte Carlo-based SciMoCa algorithm implemented in VERIQA RT MonteCarlo 3D.

The results are clear — as summarised in the study's conclusion:

"Monte Carlo dose calculation provides a signif-

icant benefit for ISDC as patient-specific quality assurance, allowing substantially more stringent acceptance criteria than an analytical algorithm."

As shown in [Figs. 6b \(Mobius3D vs Acuros XB\) und 6d \(SciMoCa vs Acuros XB\)](#) of the publication, the differing axis scales alone illustrate how widely the analytical algorithm's results scatter: Mobius3D exhibits dose differences of up to 6% and GPR values as low as roughly 30%. In contrast, SciMoCa achieves pass rates above 95% with only minor deviations close to the tolerance limit.

These results demonstrate that the more precise Monte Carlo algorithm used in VERIQA RT MonteCarlo 3D supports stricter acceptance criteria while producing significantly fewer false alarms — reducing the overall PSQA workload.

Practical Benefits for Clinical Workflows

In practice, the choice of dose calculation algorithm is also influenced by cost and resource considerations. Analytical algorithms are often supplied directly with the linear accelerator, which explains their widespread clinical adoption. However, this advantage diminishes in daily operation: analytical methods tend to produce more false alarms, require time-consuming reviews, and force clinics to use wider tolerances if workload is to be reduced.

By contrast, the effort required to commission a Monte Carlo algorithm is often overestimated. During the commissioning of [VERIQA RT MonteCarlo 3D](#), PTW provides practical support — from implementation through to routine clinical use.

VERIQA - A Future-Proof Platform

VERIQA uses clinically validated high-end algorithms across all modules and supports highly complex systems and treatment modalities such as Elekta Unity, ZAP-X, CyberKnife® and TomoTherapy®. All VERIQA methods provide true 3D

dose verification and comply with current protocols and guidelines.

The platform also allows different verification methods to be combined effectively in clinical workflows. By integrating VERIQA RT MonteCarlo 3D for pre-treatment verification with [EPID-based in-vivo dosimetry](#) (VERIQA RT EPID 3D in vivo) during treatment, all relevant error sources in the treatment chain — including patient-specific errors — can be reliably detected.

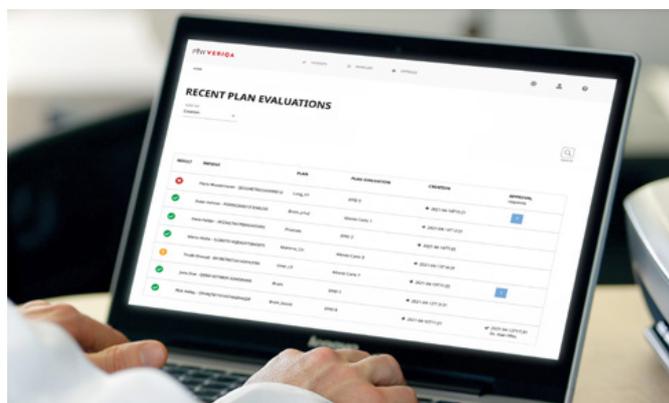


Figure 1. VERIQA RT MonteCarlo 3D: Precise Monte Carlo-based 3D dose verification with fully automated workflows from plan import to calculation, evaluation and reporting.

VERIQA RT MonteCarlo 3D: Precise Monte Carlo-based 3D dose verification with fully automated workflows from plan import to calculation, evaluation and reporting.

As a highly automated and modular platform, VERIQA increases workflow efficiency and adapts flexibly to clinical requirements. Workflows can be tailored to individual needs, implementations can be carried out step by step, and additional licences, devices or specialised applications can be added as needed — all without changing systems.

Conclusion

The results of Hoffmann et al. show impressively that Monte Carlo-based dose calculation improves the precision of patient-specific QA while reducing workload. Clinics using VERIQA RT MonteCarlo 3D benefit from fewer false alarms

and can apply stricter acceptance criteria — increasing patient safety.

In addition, Monte Carlo dose calculation offers a specific advantage for online-adaptive radiotherapy (oART): because measurement-based verification is no longer feasible in oART workflows, the daily adaptive plan can be verified quickly and accurately just before treatment using VERIQA RT MonteCarlo 3D.

References:

- [1] Hoffmann L, Linaa M-B, Møller DS, Independent secondary dose calculation for patient-specific quality assurance: Quantitative benefit of Monte-Carlo and custom beam modeling, *Journal of Applied Clinical Medical Physics* 26, e70265 (2025). <https://doi.org/10.1002/acm2.70265>



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