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WHITEPAPER

AdaptCHECK™: Real-Time Secondary QA for Adaptive Radiotherapy

Executive Summary

AdaptCHECK is a SunCHECK® module that provides independent secondary dose verification for online adaptive plans. It runs on a dedicated calculation server, receives scheduled and adapted plan data from Varian Medical Systems® Ethos™ System via DICOM, and returns pass/fail gamma results – typically in under one minute per plan.

In a clinical evaluation at New York-Presbyterian/Columbia University Irving Medical Center [1] across 70 adaptive IMRT fractions and 10 treatment sites, all sites averaged under 60 seconds, with abdominal and pelvic cases completing in approximately 22 seconds. In a head-to-head gamma comparison with MobiusAdapt (3%/2mm, 50% threshold), AdaptCHECK produced equal or higher pass rates in 8 of 10 sites. Lung cases showed the largest difference: AdaptCHECK averaged 4.57 percentage points higher, with individual fractions where MobiusAdapt fell 8 to 9 points below.

Key architectural differences from MobiusAdapt include dedicated GPU resources without queue conflicts, automatic preemption of outdated calculations for new plan iterations, report auto-saving to ARIA® Oncology Information System (OIS), and a unified SunCHECK timeline that combines adaptive QA with DoseCHECK™ and PerFRACTION™ results. Adaptive event QA results can be accessed alongside conventional patient treatment QA from within the same software with a single log in.

Overview

AdaptCHECK performs independent secondary dose calculation on both the scheduled and adapted plans generated during a Varian Medical Systems® Ethos™ System adaptive session. It uses the Collapsed Cone Convolution Superposition (CCCS) algorithm, and compares against the TPS dose via gamma analysis. Results are displayed in SunCHECK as events on the reference plan timeline.

The module is compatible with Varian Medical Systems® Ethos™ Systems v1.0 (synthetic CT) and v2.0 (HyperSight CBCT), as well as Varian Medical Systems® Halcyon™ Systems with Ethos adaptive functionality. A single dedicated AdaptCHECK calculation server supports up to two Ethos™.

Workflow Integration

AdaptCHECK fits into the standard Varian Medical Systems® Ethos™ System adaptive session as follows:

1. CBCT acquired; synthetic CT or HyperSight CBCT generated.
2. Deformed structures generated; clinician reviews and optionally modifies contours.
3. Scheduled and adapted plans calculated on the synthetic CT or Hypersight CBCT and sent to SunCHECK via DICOM (including CT, structures and dose).
4. AdaptCHECK automatically identifies incoming adaptive data via DICOM tags, links it to the reference plan, and begins dose calculation.
5. Pass/fail results delivered to the SunCHECK Patient Worklist; clinician selects a plan for treatment.
6. Post-delivery, trajectory log files are processed as fraction events for in vivo verification on the same timeline.

An existing DoseCHECK event on the reference plan is required before AdaptCHECK jobs will execute. This is to ensure that the same settings used for reference dose verification are available in AdaptCHECK.

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Verification Pipeline

The processing steps are illustrated in Figure 1.

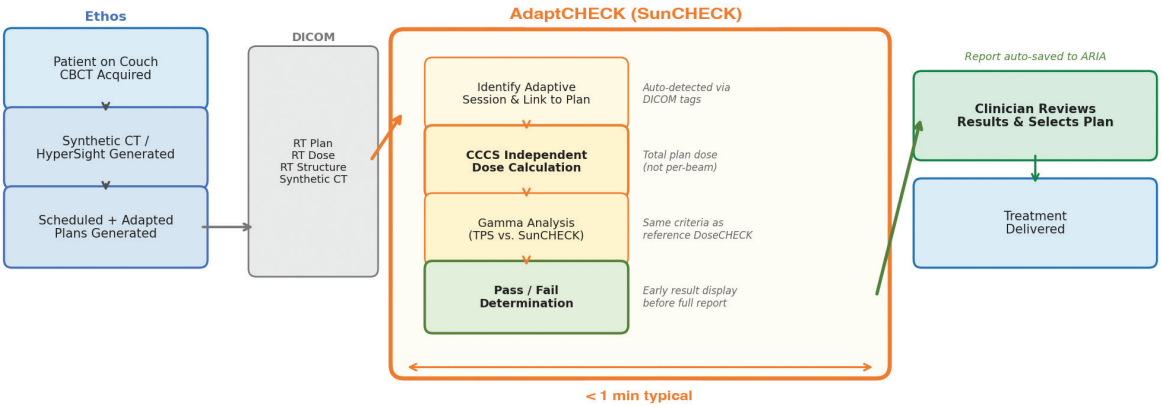

Figure 1. AdaptCHECK verification pipeline. Varian Medical Systems® Ethos™ System DICOM data is automatically identified, linked to the reference plan, and processed through independent CCCS dose calculation and gamma analysis, with pass/fail results returned to the clinician typically in under one minute.

Dose Calculation

AdaptCHECK computes an independent total plan dose on the synthetic CT or HyperSight CBCT using CCCS.

Analysis

The TPS dose is compared against the SunCHECK-calculated dose using the same gamma criteria configured for the reference plan's DoseCHECK event. Results include overall gamma pass rate, target and OAR metrics (universal or custom), and DVH data. Reports can be auto-saved to ARIA.

Session Management

When Varian Medical Systems® Ethos™ System sends multiple plan iterations for the same fraction (e.g., after structure modification), AdaptCHECK cancels the in-progress calculation within seconds and begins processing the newest data. A system preference controls whether earlier results are retained on the timeline or auto-deleted. A further setting controls whether calculations are performed for the scheduled plan, or just for the adapted plan. This feature is useful if the adaptive plan is always selected.

Performance

AdaptCHECK targets verification of two IMRT plans within the on-couch treatment window. Performance results from two clinical sites are given below:

New York-Presbyterian/Columbia University Irving Medical Center [1], n=70 fractions. Average QA times by treatment site are shown in Figure 2. All sites averaged under one minute, with abdominal and pelvic cases completing in approximately 22 seconds.

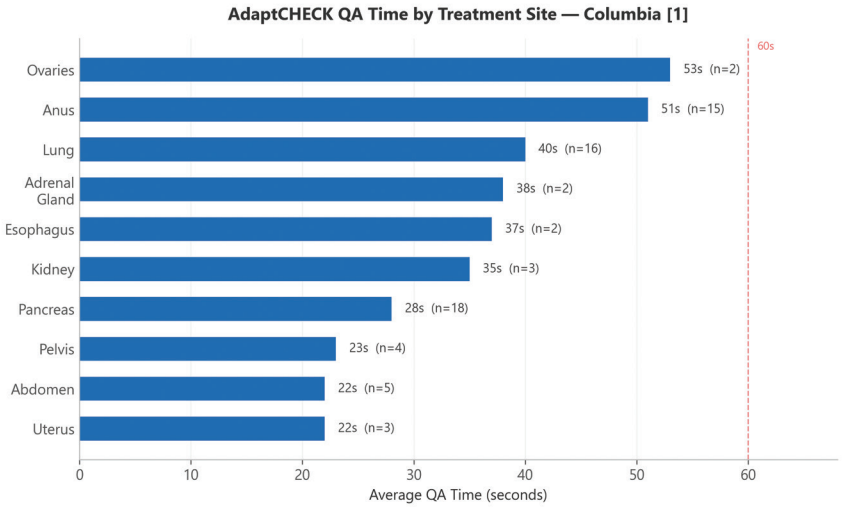

Figure 2. Average AdaptCHECK QA time by treatment site across 70 adaptive fractions at Columbia [1]. Dashed line indicates 60-second threshold. All sites completed well under one minute.

Henry Ford Health - Henry Ford Hospital [3], n≈330 jobs, 3.5 months. Production deployment from January to May 2026. Overall average: ~40s | Median: ~37s | Range: 14s–76s. 100% success rate across all completed jobs. Monthly performance is shown in Figure 3.

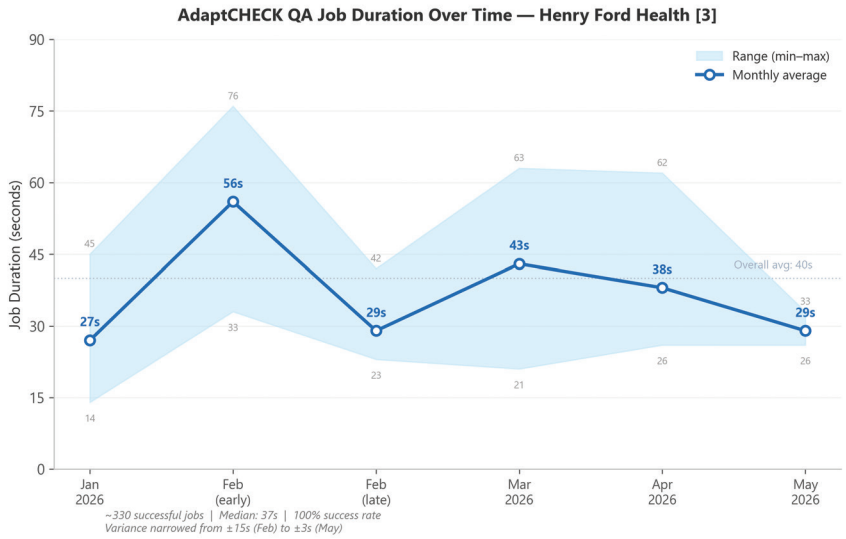

Figure 3. AdaptCHECK job duration over time at Henry Ford Health [3], showing monthly averages (line) and min–max range (shaded band) across approximately 330 successful jobs. Variance narrowed significantly from ±15s in February to ±3s in May, with the most recent period averaging 29 seconds.

Architecture

AdaptCHECK runs on a dedicated calculation server with its own DICOM listener and job processor, isolated from the primary SunCHECK server that handles DoseCHECK and PerFRACTION jobs. This ensures adaptive calculations never queue behind reference plan or fraction analysis work. Two GPUs per Varian Medical Systems® Ethos™ System are required (one GPU if scheduled plan calculations are disabled via system preference).

Dosimetric Accuracy

Clinical comparison data from Columbia [1] across 70 adaptive fractions, using gamma criteria of 3%/2mm with 50% dose threshold:

- 47 of 70 fractions (67%) showed < 1 percentage point difference between AdaptCHECK and MobiusAdapt.
- AdaptCHECK gamma pass rates were equal to or higher than MobiusAdapt in 8 of 10 treatment sites.
- Only abdomen and pelvis showed MobiusAdapt marginally higher (< 0.4 pp).

Average gamma pass rate difference (AdaptCHECK minus MobiusAdapt) by site: abdomen -0.11, pelvis -0.02, uterus +0.06, kidney +0.09, ovaries +0.10, pancreas +0.27, anus +1.11, esophagus +1.46, adrenal gland +1.95, lung +4.57%.

Average gamma pass rate difference (AdaptCHECK minus MobiusAdapt) by site is shown in Figure 4.

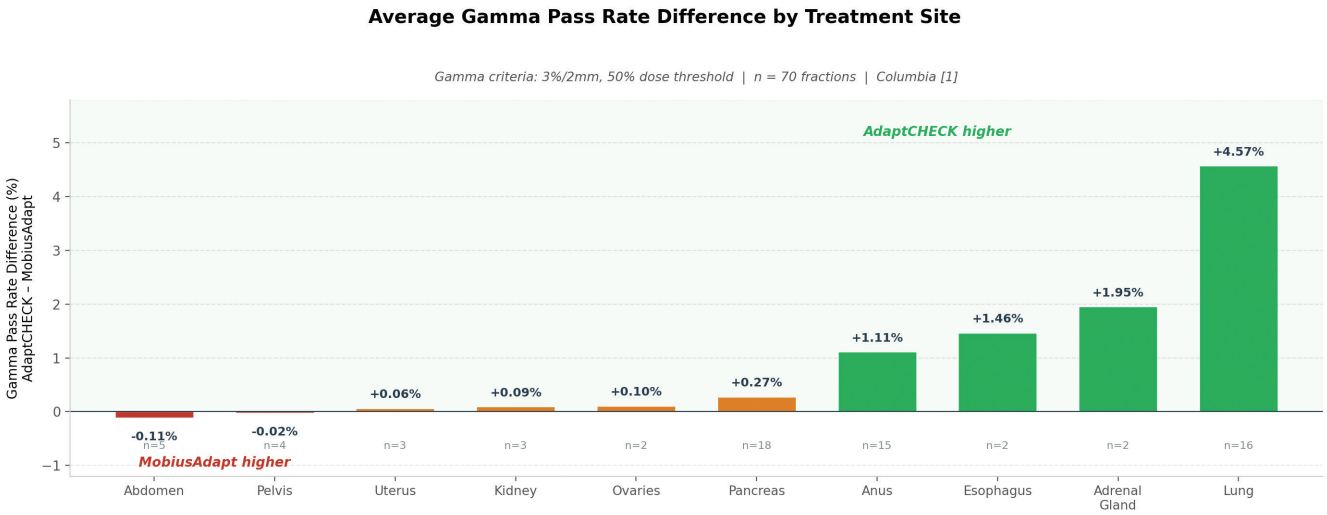

Figure 4. Average gamma pass rate difference (AdaptCHECK minus MobiusAdapt) across 10 treatment sites, 70 adaptive fractions. Gamma criteria: 3%/2mm, 50% dose threshold. Positive values indicate higher AdaptCHECK pass rates. Data from Columbia [1].

Lung cases showed the largest discrepancy, with individual fractions where MobiusAdapt gamma pass rates fell 8 to 9 percentage points below AdaptCHECK. MobiusAdapt values dropped as low as ~86% while AdaptCHECK remained in the 97-100% range. This pattern was consistent across anatomically heterogeneous sites where tissue density variations begin to challenge dose calculation accuracy.

Independent Evaluation: BHRUT (UK NHS)

An independent evaluation at Barking, Havering & Redbridge University Hospitals NHS Trust (BHRUT) [4], presented at ESTRO, compared AdaptCHECK against MobiusAdapt across a range of clinical plan types including 7-, 9-, and 12-field IMRT as well as 2- and 3-arc VMAT. Using tighter gamma criteria of 2%/2mm, AdaptCHECK achieved an average gamma pass rate of 98.9%, compared to 98.7% for MobiusAdapt.

A Bland-Altman analysis of gamma pass rates across all fractions found a mean bias of only +0.39% (AdaptCHECK minus MobiusAdapt) with tight limits of agreement and no trend across the performance range, confirming no systematic difference between the two systems.

Beyond gamma, BHRUT evaluated PTV mean dose difference (Dmean) relative to the Varian Medical Systems® Ethos™ System TPS dose. AdaptCHECK maintained a consistent Dmean of approximately 1% with a narrow spread (~0.8–1.0% range), while MobiusAdapt exhibited wider variability (up to 2.8% range) and a tendency toward underestimation. This pattern held across longitudinal analysis: from the reference plan through final treatment fractions, AdaptCHECK Dmean remained stable at approximately 1%, whereas MobiusAdapt showed drift toward slight negative bias. The tighter PTV dose consistency observed with AdaptCHECK suggests more reliable agreement with the TPS across the full course of treatment.

Dose Calculation Engine Validation

The CCCS algorithm underlying AdaptCHECK – the Sun Nuclear Dose Calculator (SDC) – has been validated at scale against all major commercial TPS algorithms [2]. A study of 266 custom beam modeling reports spanning 4,845 target structures across multiple linac platforms, MLC types, and energies assessed target median dose differences (D50 difference between the SDC and TPS for the hottest PTV).

Across all structures, the mean difference in median dose was 0.02% (SD 1.19%), demonstrating that the SDC introduces no systematic bias relative to TPS calculations. Agreement was consistent across TPS platforms: Varian Medical Systems® Eclipse™ (n=2,448, median 0.05%), Monaco (n=701, median 0.09%), and RaySearch RayStation® (n=808, median -0.05%) all showed tight distributions.

The SDC showed strong agreement with Monte Carlo calculations, with a median difference in median dose of 0.15% (n=581). Against Acuros XB (LBTE solver), the median difference was 0.04% (n=1,037).

The very low bias versus both Monte Carlo and Acuros XB, across thousands of clinical plans from hundreds of institutions, provides a strong dosimetric foundation for AdaptCHECK's role as an independent secondary check – and is consistent with the gamma pass rate advantage over MobiusAdapt observed in the Columbia data.

Structure Handling

Dosimetric goals, tolerance criteria, and structure-specific settings propagate automatically from the reference plan to each adaptive session. AdaptCHECK thus evaluates adaptive plans using the same metrics configured for the reference plan.

AdaptCHECK vs. MobiusAdapt

MobiusAdapt is bundled Varian Medical Systems® Ethos™ System, but does not mandate its use – the requirement is that DICOM data be exported for QA purposes, and any compliant secondary check system can serve this role. The architectural and functional differences are summarized in Figure 5.

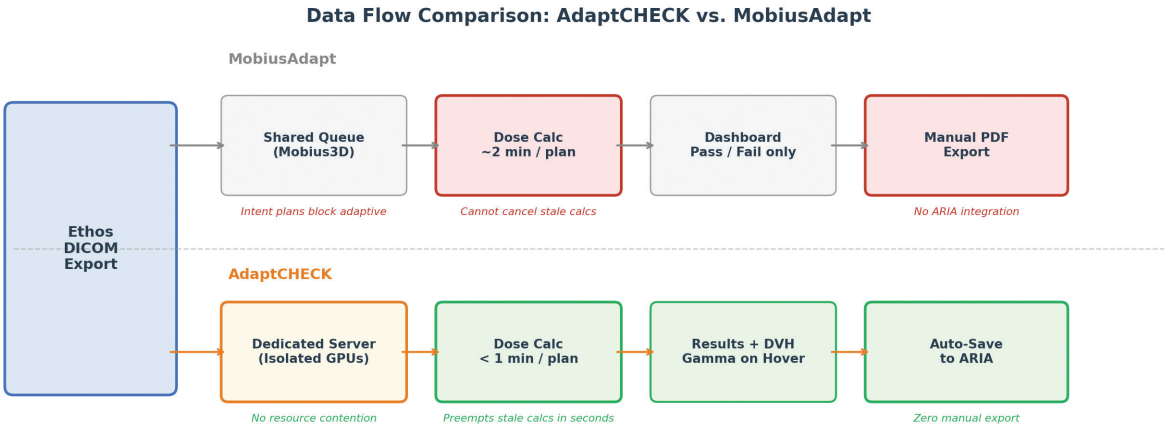

Figure 5. Data flow comparison of AdaptCHECK and MobiusAdapt processing architectures. Clinical performance data from Columbia [1].

Speed

MobiusAdapt reports ~2 minutes per IMRT plan, acknowledged in Varian documentation as too long for the online adaptive workflow. AdaptCHECK averages under one minute across all evaluated treatment sites.

Calculation Preemption

MobiusAdapt cannot cancel in-progress calculations; when a new plan iteration arrives, the outdated calculation runs to completion. AdaptCHECK interrupts stale calculations within seconds for quicker prioritization of the new incoming plans.

Resource Isolation

MobiusAdapt shares a processing queue with routine Mobius3D jobs. Treatment intent plans sent during treatment hours can delay adaptive calculations. AdaptCHECK uses a dedicated server; DoseCHECK and PerFRACTION jobs route only to the primary server.

ARIA OIS Integration

MobiusAdapt requires manual PDF export. AdaptCHECK auto-saves reports to ARIA.

Data Retention

MobiusAdapt purges DICOM files after 90 days. SunCHECK has no forced purge.

Gamma Accuracy

See Dosimetric Accuracy section above. AdaptCHECK produced higher gamma pass rates in 8 of 10 sites, with the largest advantage in heterogeneous anatomy.

Compatibility and Configuration

- **Varian Medical Systems® Ethos™ System versions:** v1.0 (synthetic CT) and v2.0 (HyperSight CBCT)
- **Machines:** Varian Medical Systems® Ethos™ and Halcyon™ Systems with Ethos adaptive capability
- **Algorithm:** CCCS only
- **Licensing:** AdaptCHECK license (also enables DoseCHECK) + PerFRACTION Calculate license
- **GPU requirement:** 2 GPUs per Varian Medical Systems® Ethos™ System machine (1 if scheduled plan calculation disabled)
- **Server capacity:** 1 dedicated server supports up to 2 Varian Medical Systems® Ethos™ Systems
- **Beam model:** Generic Varian Medical Systems® Ethos™ and Halcyon™ Systems model provided for CCCS
- **DICOM routing:** Varian Medical Systems® Ethos™ System exports adaptive session data to AdaptCHECK server; reference plans and delivery logs route to primary SunCHECK server

AdaptCHECK is a module within SunCHECK. For more information, contact your Sun Nuclear representative.

References

1. New York-Presbyterian/Columbia University Irving Medical Center, private communication.
2. Sun Nuclear, "A Large-Scale Comparison of the Sun Nuclear Dose Calculator Algorithm," MKTG-3386, January 2025.
3. Henry Ford Health - Henry Ford Hospital, production AdaptCHECK deployment data, January–May 2026.
4. G. Kidane, “Assessing Sun Nuclear AdaptCHECK for Independent Plan Verification in Online Adaptive Radiotherapy,” presented at ESTRO, Barking, Havering & Redbridge University Hospitals NHS Trust.