Automation of QIAcuity® digital PCR in high-throughput laboratories: Driving efficiency, safety and workforce empowerment

Introduction

The integration of advanced automation technologies into high-throughput laboratories is transforming modern analytical workflows. By using robotics, intelligent process control and data-driven systems, laboratories can process thousands of samples with unprecedented speed and consistency. This evolution increases throughput and the reliability and reproducibility of scientific results.

A critical dimension of this transformation is safety. Automated platforms significantly reduce human error, minimize direct exposure to hazardous substances and enforce standardized protocols that align with stringent regulatory requirements. These measures protect personnel and safeguard the integrity of generated data, ensuring compliance and traceability across all stages of the workflow.

Beyond operational efficiency, automation delivers tangible benefits for laboratory staff. By delegating repetitive and labor-intensive tasks – such as pipetting, sample preparation and plate handling – to automated systems, skilled professionals can focus on higher-value activities like data interpretation, method development and innovation. This shift fosters a more engaging work environment, improves job satisfaction and optimizes the use of scientific expertise.

Taken together, automation in high-throughput laboratories improves precision, safety, productivity and workforce efficiency to meet and exceed the growing demands of modern science.

Manual vs automated workflows

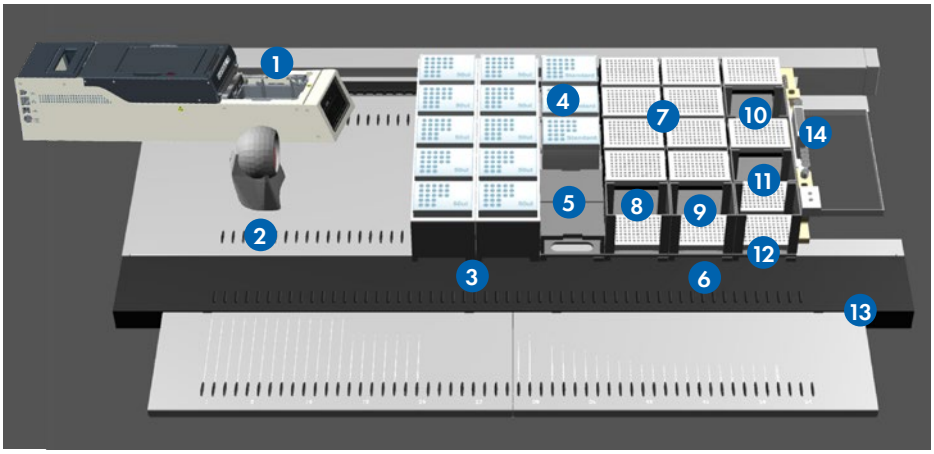
The QIAcuity is designed as a walk-away instrument that integrates and automates all plate processing steps after plate preparation. Plate preparation involves pipetting the target reagents and mastermix into the wells of the QIAcuity nanoplates and closing the wells manually with the QIAcuity Nanoplate Seal.

To automate the entire workflow, the plate preparation step, specifically the pipetting and filling of the QIAcuity nanoplate can be carried out on the Hamilton Microlab® STAR™ instrument. The filling (priming) of the nanoplates is accomplished by a proprietary consumable – the Nanoplate Priming Plug – that has been co-developed by QIAGEN and Hamilton for Hamilton Microlab STAR instruments with CO-RE II® channel technology.

The filling step is followed by the automated sealing of the nanoplate with PCR plate sealing foils before the nanoplate is loaded onto the QIAcuity instrument. In the automated workflow setup, only the rolling of the nanoplates followed by the PCR cycling, imaging and dPCR analysis is covered by the QIAcuity instrument.

Set-up of the automated workflow

The Hamilton STAR deck layout for automated QIAcuity nanoplate handling up to eight nanoplates per run is shown in Figure 1.



1. Hamilton Plate Sealer
2. Honeywell Orbit Scanner
3. 2x Tip Carrier (50 µL Tip Racks)
4. 3x NTR-Module (Priming Plugs)
5. 2x Tube Module (2 mL Mastermix Tubes)
6. 3x Sample Plate Carrier
7. 8x Plate Module (sample plate & nanoplates)
8. 1x Stacker Module (unprocessed sample plates)
9. 1x Stacker Module (processed sample plates)
10. 1x Plate Module (preparation and priming of nanoplates)
11. 1x Stacker Module (nanoplates unprocessed)
12. 1x Stacker Module (sealed nanoplates)
13. AL 1D Barcode Reader
14. QIAcuity Waste Chute

Figure 1. Hamilton STAR deck layout conception for fully automated QIAcuity Nanoplate workflow processing.

The QIAcuity Nanoplate Priming Plugs Kit (cat no. 250088) is used on the Hamilton STAR instrument to fill the QIAcuity nanoplate microstructure by applying a positive air pressure to the sample input wells with a dispense drive of the Hamilton pipetting head. After filling the microstructures of the nanoplate, the process is completed by applying a standard PCR seal to the QIAcuity nanoplate (Figure 2).

The following equipment and consumables are required for the automated workflow:

- QIAcuity Digital PCR System with software 3.1.1 or higher
- QIAcuity Nanoplate: 8.5k 96-well (cat no. 250021) or 26k 24-well (cat no. 250001)
- Hamilton STAR instrument with 8 CO-RE II 1mL channels and Hamilton VENUS 6.3.2 software (or higher)

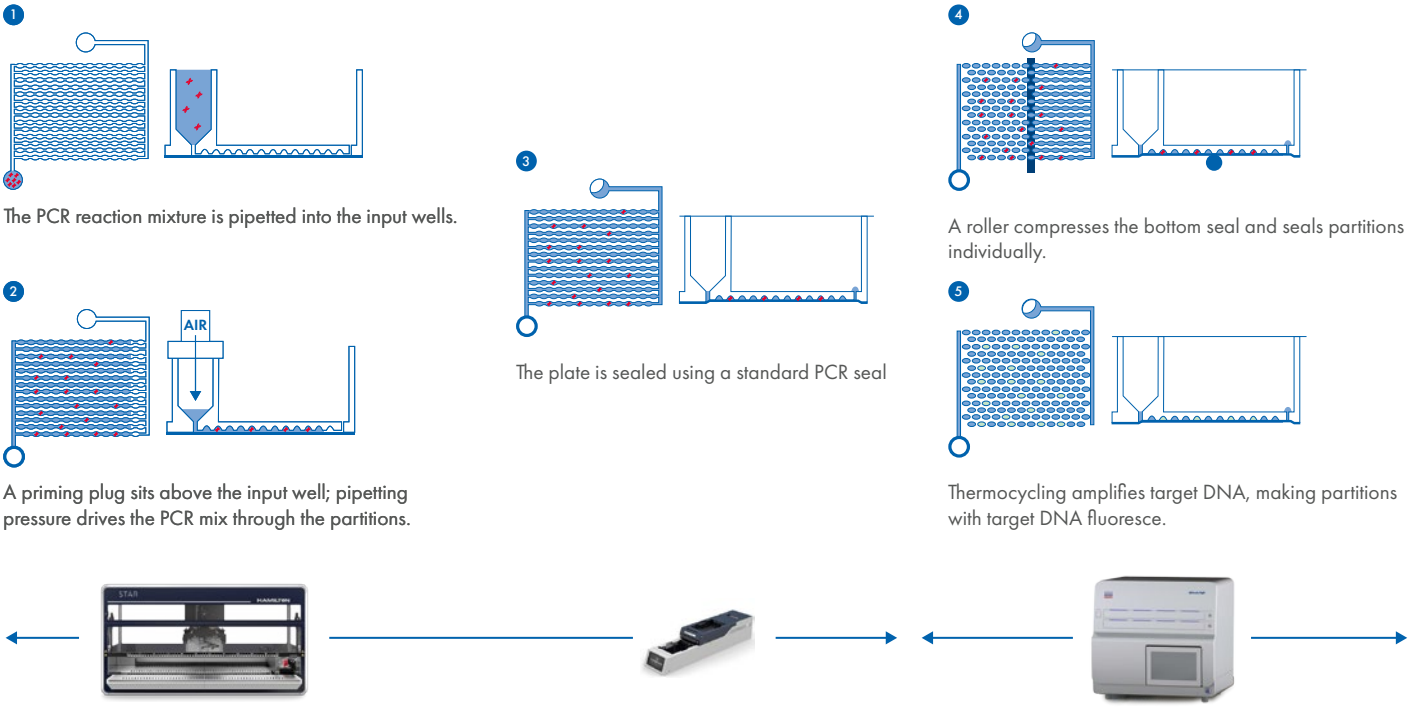


Figure 2. Automated QIAcuity dPCR workflow using the Hamilton STAR instrument.

Run-time analysis of the manual vs automated workflows

A comparative analysis of the manual QIAcuity workflow and the fully automated QIAcuity workflow on Hamilton STAR is shown in Figure 3. The comparison highlights the differences in both total run time and hands-on time required to process QIAcuity nanoplates using each approach.

By visualizing these metrics for varying plate numbers, the figure demonstrates how automation with the Hamilton STAR instrument streamlines the workflow, significantly reducing manual intervention while maintaining overall process efficiency. Processing of eight plates, for example, requires about 10 minutes of hands-on time, compared to more than 2.5 hours in the manual workflow. Furthermore, the total runtimes of the automated workflows are similar to their manual counterparts.

This comparison provides a clear overview of the operational benefits gained through automation, especially in high-throughput laboratory settings.

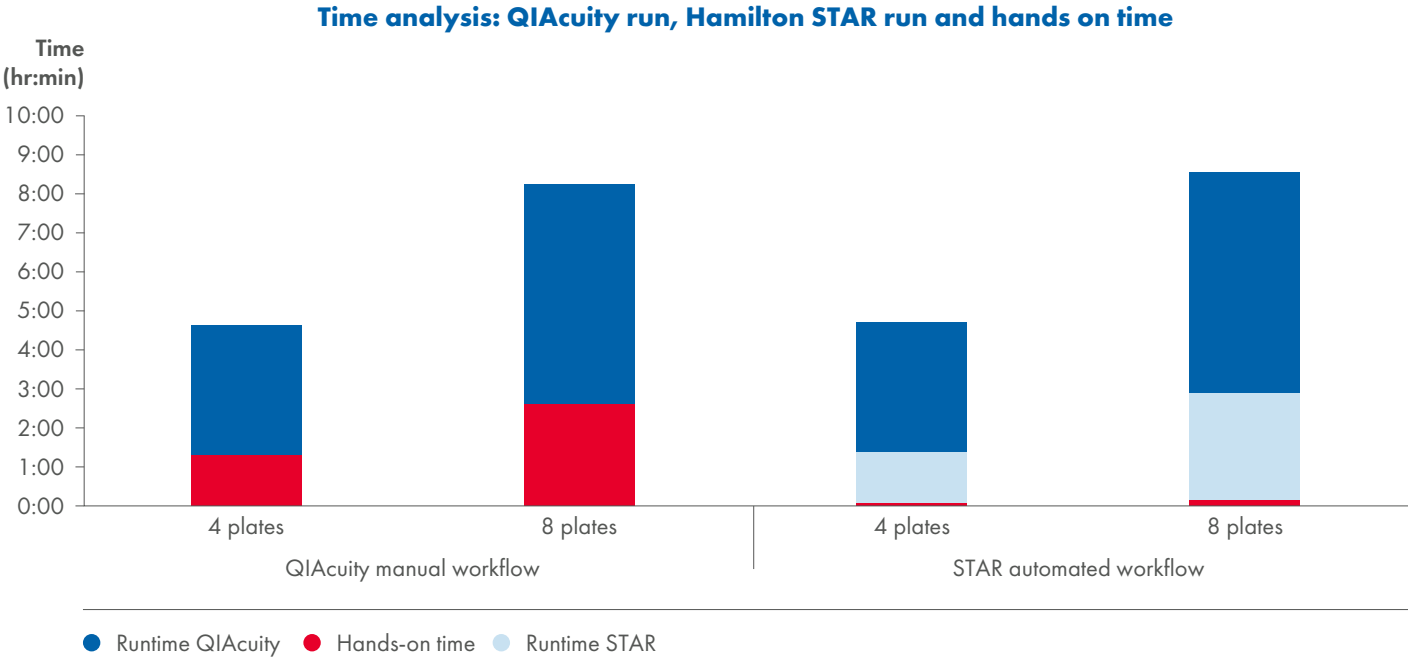


Figure 3. Automation with the Hamilton STAR reduces manual intervention while maintaining process efficiency.
Runtime analysis was performed for a manual workflow compared to a fully automated workflow on Hamilton STAR. Data is based on QIAcuity Nanoplates 8.5k 96-well on the QIAcuity Eight instrument. QIAcuity runtime is defined as the time required by the QIAcuity instrument to process the nanoplate, including priming, rolling, cycling and imaging. STAR runtime is defined as the time required by the Hamilton STAR robot to pipette the reaction mix and sample into the nanoplate, fill the nanoplate partitions (nanoplate priming) and seal the nanoplate. Hands-on time is defined as the time the user needs to actively work on plate preparation or to start the instruments.

Performance data of the manual and automated workflows

The manual QIAcuity workflow and the automated workflow on Hamilton STAR show comparable filling quality and concentration of the Nanoplate 8.5k 96-well partitions (Figure 4). Both workflows yield a similar mean number of valid partitions (~8200 for the automated workflow and ~8400 for the manual workflow). The automated workflow results in mean concentrations of ~300 cp/µL, comparable to the mean concentration of the manual workflow (~325 cp/µL).

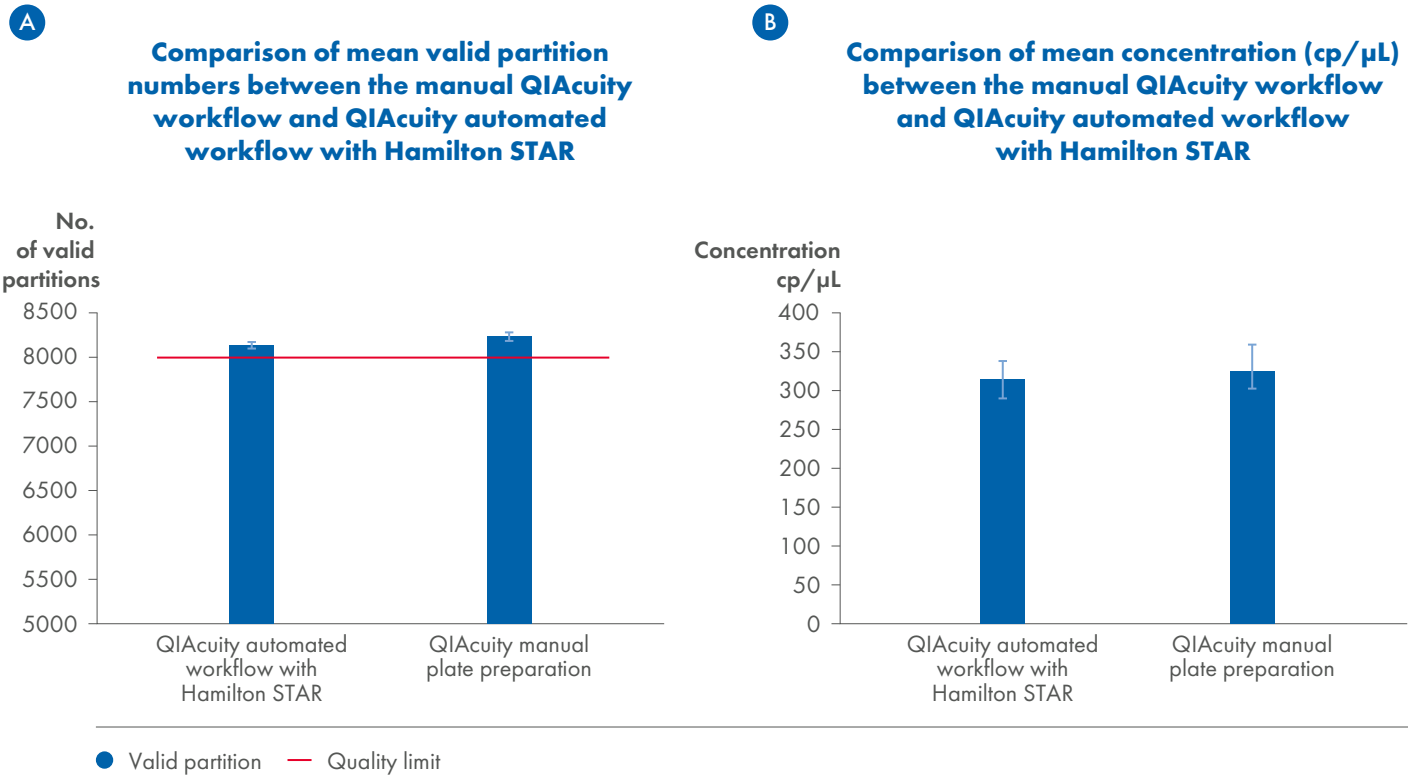


Figure 4. The manual QIAcuity workflow and automated workflow on Hamilton STAR show equivalent performance for Nanoplate 8.5K 96-well.
Mean valid partition comparison between the manual QIAcuity workflow and automated workflow on Hamilton STAR (n=8 plates per method) in conjunction with QIAcuity analysis using Nanoplates 8.5k 96-well (A). Mean concentration (cp/µL) comparison between the manual QIAcuity workflow and the Hamilton STAR automated workflow (n=8 plates per method) in conjunction with QIAcuity analysis using Nanoplates 8.5k 96-well (B).

The same comparable performance is observed for both workflows when using Nanoplates 26k 24-well (Figure 5). The mean number of partitions for both types of workflows is ~25,000. The mean concentration of the automated workflow is ~200 cp/µL, whereas the manual workflow results in a comparable mean concentration of ~210 cp/µL.

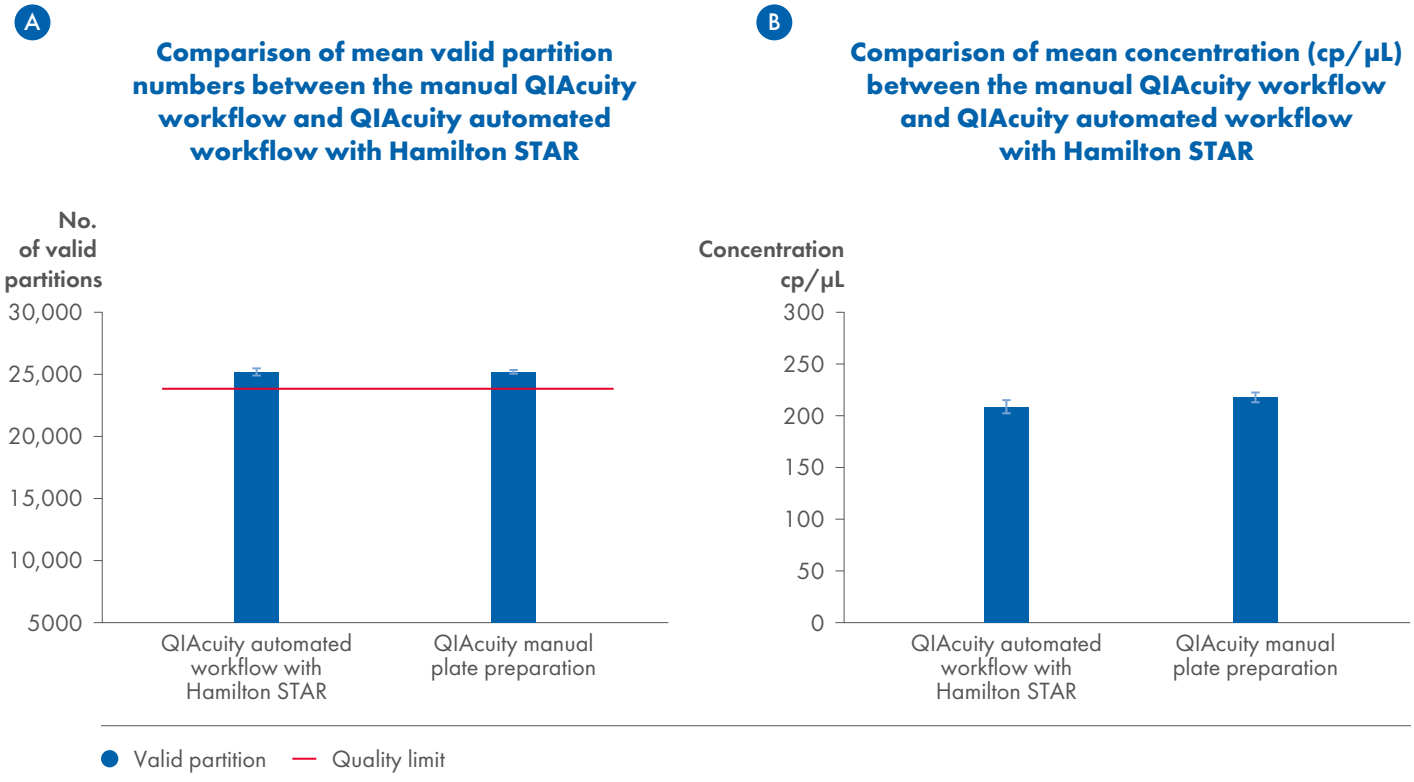


Figure 5. The manual QIAcuity workflow and automated workflow on Hamilton STAR perform comparably for Nanoplates 26K 24-well.
Mean valid partition comparison between the manual QIAcuity workflow and automated workflow on Hamilton STAR (n=8 plates per method) using Nanoplates 26k 24-well (A). Mean concentration (cp/µL) comparison between the manual QIAcuity workflow and Hamilton STAR automated workflow (n=8 plates per method) using Nanoplates 26k 24-well (B).

Conclusion

Both the standard manual QIAcuity workflow and the fully automated QIAcuity workflow on the Hamilton STAR deliver equivalent performance in terms of filling quality and concentration results. The automated workflow reduces hands-on time from hours to minutes, streamlines the overall process and enhances operational efficiency without compromising data quality. These advantages are especially relevant for high-throughput laboratories, which must process numerous samples under strict regulations.

Ordering information

Product	Description	Cat. no.
QIAcuity Four Platform System	Four-plate digital PCR instrument for detecting up to 5 fluorescent dyes or up to 8 fluorescent dyes operating under software version 3.1 or higher, enabling up to 12plex analysis, notebook computer, barcode scanner, roller,USB flash memory and QIAcuity Software Suite: includes installation, training, and 1 preventive maintenance visit. 1 year warranty on labor, travel, and parts.	911042*
QIAcuity Eight Platform System	Eight-plate digital PCR instrument for detecting up to 5 fluorescent dyes or up to 8 fluorescent dyes operating under software version 3.1 or higher, enabling up to 12plex analysis, notebook computer, barcode scanner, roller,USB flash memory and QIAcuity Software Suite: includes installation, training, and 1 preventive maintenance visit. 1 year warranty on labor, travel, and parts.	911052*
QIAcuity Nanoplate Priming Plugs (24x96)	24 racks each carrying 96 Priming Plugs for the automated filling of QIAcuity Nanoplates using a Hamilton Microlab® STAR™ Line instrument	250088
QIAcuity Nanoplate 8.5k 96-well (10)	10 QIAcuity Nanoplate 8.5k 96-Well, 11 Nanoplate Seals	250021
QIAcuity Nanoplate 26k 24-well (10)	10 QIAcuity Nanoplate 26k 24-Well, 11 Nanoplate Seals	250001
Hamilton Microlab® STAR™ and deck items	Please contact Hamilton.	

*additional instrument configurations and service bundles available.

For up-to-date licensing information and product-specific disclaimers, see the respective QIAGEN kit instructions for use or the user operator manual. QIAGEN instructions for use and user manuals are available at www.qiagen.com or can be requested from QIAGEN Technical Services (or your local distributor). All figures and underlying data are from the QIAGEN R&D Department. QIAcuity is for Research Use Only. Not for use in diagnostic procedures.

Find out more about the QIAcuity Digital PCR System:
www.qiagen.com/qiacuity