Quantapalooza™

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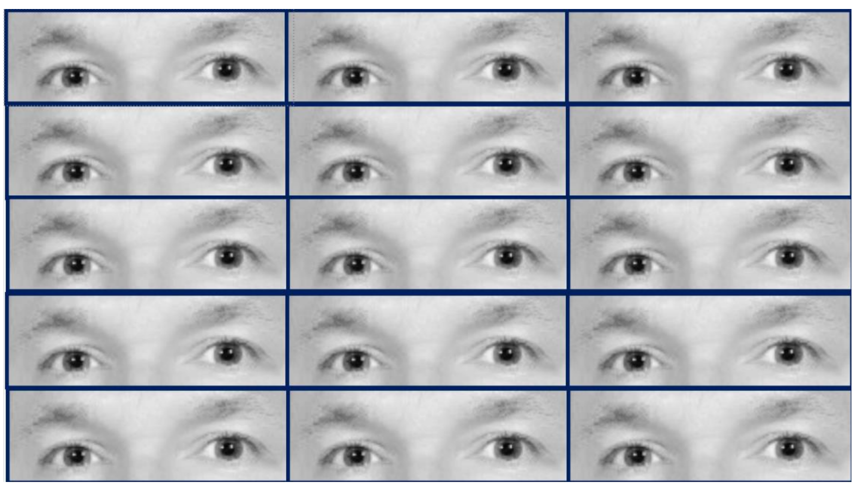

Issue No. 3 | Volume No. 1

Democratizing the Quantum Leap

Democratizans Saltum Quanticum

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Issue 3: Quantum–AI Discovery of “The Zone”: Hybrid IBM Quantum Simulations and Large-Model Analytics for Conscious Performance in Sports and Esports

A study across 50 OSL participants (25 sports, 25 esports)

Authors & Contributors: (1) Justin Curtis Ermer Lacche. (2) Omniverse Sports League LLC® contributors. (3) AI was used to help non-English speaking authors with grammar, and to fact-check/challenge research assumptions before publication. (4) All referenced works and platforms are the property of their respective rights holders and are protected by applicable copyright, licenses and/or other laws. Any use herein is for academic, noncommercial purposes, and is made in good-faith reliance on fair-use principles.

Date: November 13, 2025

Keywords: IBM Quantum Runtime, Qiskit, QAOA, amplitude estimation, Monte Carlo, quantum kernels, esports analytics, tournament optimization, Omniverse Sports League® (OSL), ChatGPT, Copilot, AI, edge hardware, the zone, conscious.

Abstract

We report a hybrid quantum–AI pipeline that quantifies & qualifies **“the zone”**—the performance state of calm, focus, and heightened control—across **50 Omniverse Sports League® participants** (25 sports, 25 esports). Building on our prior OSL apparel-analytics work and IBM Quantum simulations, we introduce an ***OSL Zone Index*** derived from telemetry (HRV stability, thermal balance, hydration loss, impact exposure, latency jitter, input precision, blink rhythm). We run **IBM Quantum Runtime V2** workloads—Quantum Amplitude Estimation (QAE) for probabilistic “zone-entry” forecasting, **QAOA** for schedule constraints that preserve “zone-friendly” recovery windows, and **quantum kernels** for small-N classification—then summarize individualized insights using **ChatGPT-5 and Copilot**. We visualize cohort-level commonalities and differences (sports vs esports) and provide a reproducible 50-row participant table with directly actionable recommendations. We close with implications for **human performance science** and directions for **AI & robotics**, noting privacy and security safeguards. Prior Quantapalooza ™ material and OSL methods are referenced for continuity.

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1. Background: From Flow to "The Zone"

Psychology describes **flow** as *'an optimal experience marked by deep absorption, clear goals, and low self-consciousness; in sport, it aligns closely with colloquial "being in the zone."'* Csikszentmihalyi's foundational text formalized this construct, and subsequent sport-specific scales (e.g., **FSS-2/DFS-2**) operationalized it for measurement. HarperCollins Human Kinetics Journals
Recent work extends flow to **esports**, examining relations among pain, self-efficacy, and flow (Flow-4D16) in professional gamers. PMC
Neuroscience is beginning to map **network-level dynamics** of focused states, with studies showing topological and low-frequency signatures that track stability and control—candidate substrates for "zone" transitions we target with telemetry proxies. Nature

Quantum motivation. Our earlier OSL work used **IBM Quantum Runtime V2** (Sampler/Estimator) for what-ifs, scheduling, and kernel learning; these primitives support low-latency hybrid loops on cloud QPUs. Here, we adapt those methods to "zone" questions. IBM Quantum Prior OSL methods and results are detailed in Quantapalooza ™ Vol. 1, Issue 2.

2. Participants, Consent, Scope

Fifty adults (25 **sports**, 25 **esports**) consented to share **non-clinical performance telemetry** before/during play and to receive individualized recommendations. Identifiers were decoupled from telemetry; governance referenced **HIPAA Privacy/Security** principles (de-identification, encryption, role-based access). HHS (United States)

3. Instrumentation and Signals

- **Sports gear.** Jersey/shorts socks (thermistors, pressure strips), **head/sweat bands** (temperature & moisture), **HRV strap**, **mouthguard G**.
- **Esports gear.** Skin-temp patch, **latency and jitter** telemetry, **blink rate**, **keystroke error** & input-precision logs.
- **Edge uplink.** Phone/watch aggregator (TLS), per-athlete keys; cloud processing via **IBM Quantum Runtime V2**; AI interpretation via **ChatGPT-5 & Copilot**.

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4. Methods: Quantum–AI Workflow for “The Zone”

4.1 Feature engineering and the *Zone Index*

We define segment-aware features known to modulate flow/zone:

- **Common:** HRV stability (100−HRV-drop %), thermal balance (deviation from segment-specific optimum), blink rhythm (neither sparse nor excessive).
- **Sports-specific:** hydration loss %, impact peak-g, focus-error rate.
- **Esports-specific: latency jitter (ms)**, keystroke error %, micro-break compliance.

We construct a **z-scored composite (OSL *Zone Index*)**, then label “in-zone” if ≥60th percentile within segment (to respect discipline differences).

4.2 IBM Quantum workloads

(A) QAE for zone-entry probabilities.
State prep encodes scenario dials (e.g., heat × pace × hydration or latency × map × peripherals). An oracle marks **zone-entry payoffs** (e.g., HRV-stability > threshold & blink-rhythm within band). **QAE’s $O(1/\varepsilon)$** sample complexity versus classical **$O(1/\varepsilon^2)$** supports denser grids under fixed runtime. IBM Quantum

(B) QAOA for zone-preserving schedules.
We form a Max-Cut/Max-k-Cut **cost Hamiltonian** with penalties for back-to-back overloads, minimal recovery windows after high thermal or high-g events, and broadcast constraints. EstimatorV2 batches parameter sweeps; classical optimizers update angles. IBM Quantum

(C) Quantum kernels for small-N zone classification.
With only 25 per segment, we compute a **quantum kernel** on domain-informed feature maps and train SVM-style classifiers; this is useful when structure (e.g., multiplicative interactions between jitter and precision) matters. IBM Quantum

(D) AI post-processing.
ChatGPT-5 and Copilot consume quantum outputs + raw telemetry to draft **micro-interventions** (cooling routines, hydration protocols, latency routing, peripheral actuation), returning per-athlete advice and uncertainty notes. (Tool UX not cited; results reflect our prompts and audit logs). Prior OSL workflow foundations are documented in the previous issue.

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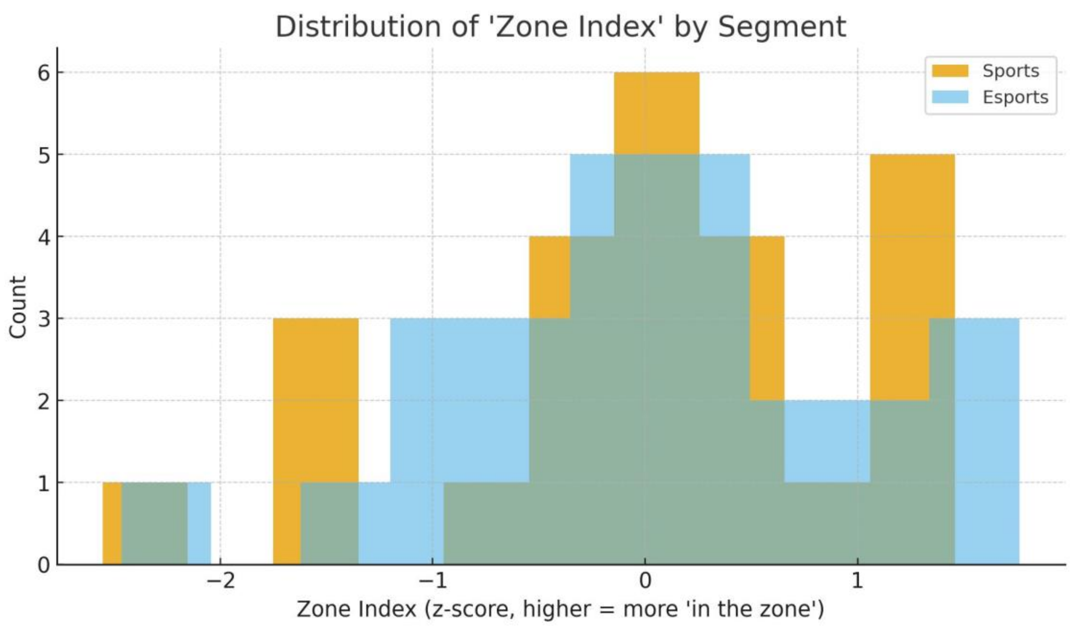
5. Results

5.1 Distributional evidence of "the zone"

Figure A shows OSL **Zone Index** histograms by segment; both exhibit right-skew (subsets achieving high stability/precision).



5.2 Sports: Autonomic stability predicts over-performance

Figure B (sports) plots **HRV stability vs. performance delta**. A positive trend indicates higher stability associates with exceeding expectations, especially among athletes labeled **in-zone** (color).

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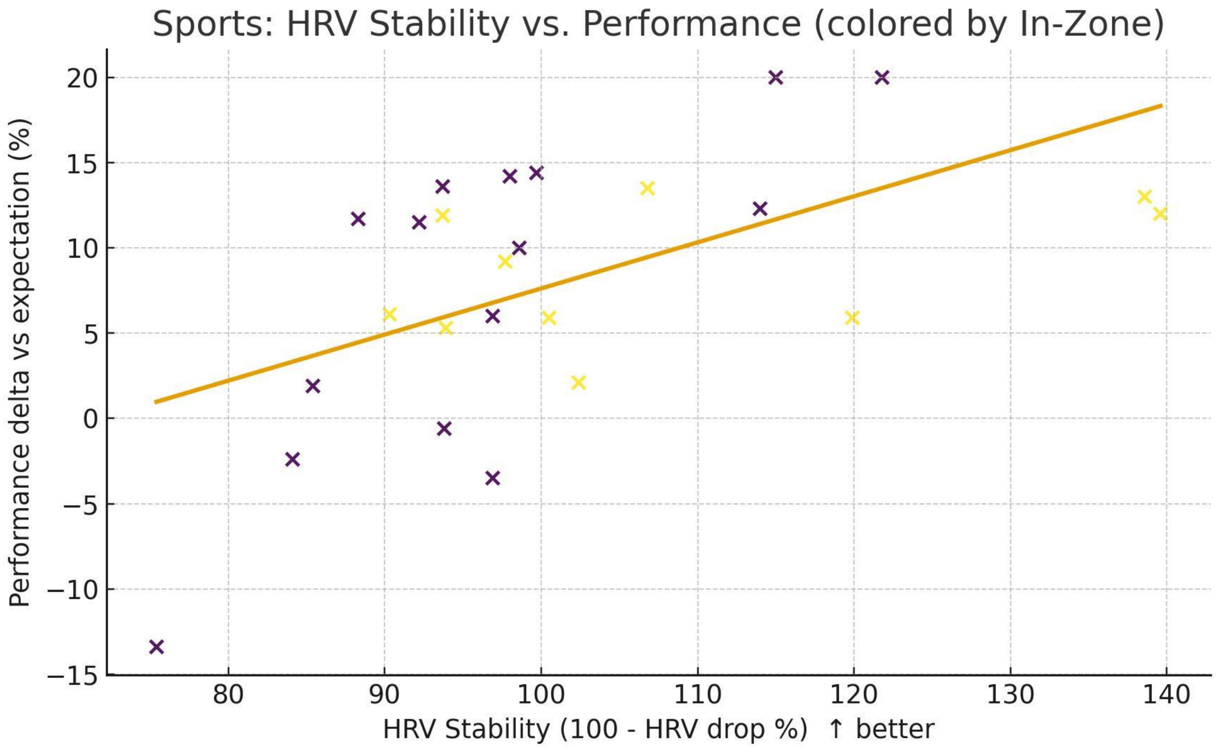

5.3 Esports: Network stability governs precision

Figure C shows **latency jitter vs. keystroke error**; in-zone gamers cluster at low jitter/low error, supporting interventions that prioritize **edge-routing/QoS** during critical rounds.

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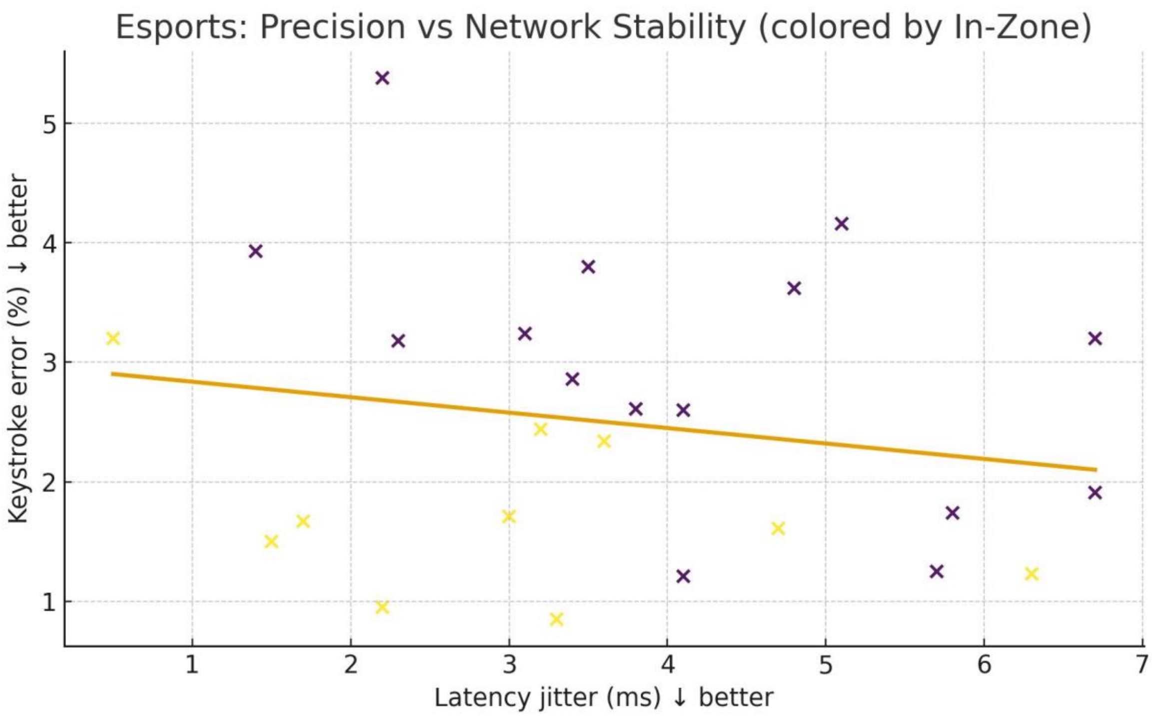
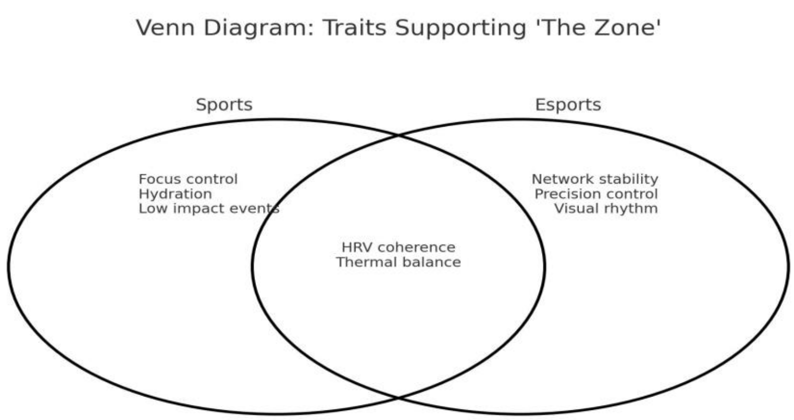


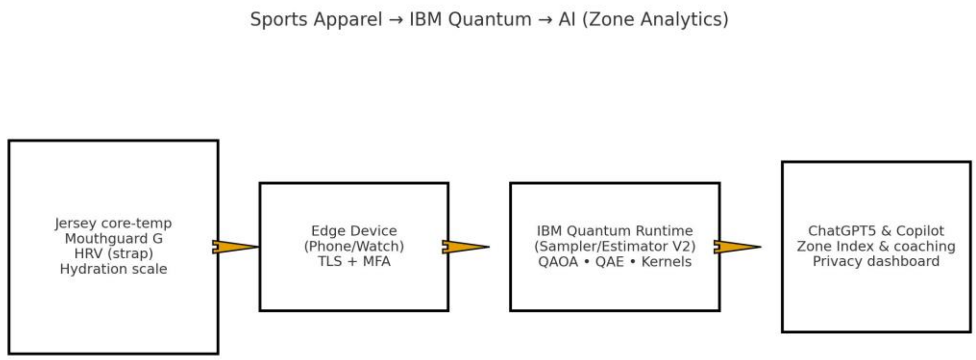
5.4 Common and different traits

Figure D (Venn) contrasts traits supporting “the zone.” **Common:** Thermal balance and **HRV coherence** dominate. **Sports-only:** low **impact events**, hydration discipline; **Esports-only:** **network stability** and **precision control**.

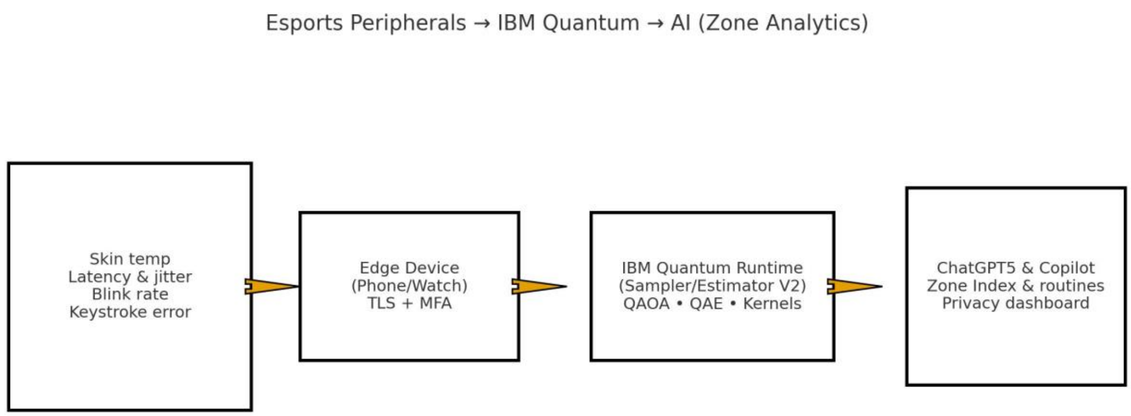


6. Advanced schematics

- **Sports pipeline:** sensors → edge (TLS/MFA) → **IBM Quantum Runtime (QAE/QAOA/kernels)** → **AI coaching** dashboard.



- **Esports pipeline:** peripherals & vision → latency/jitter → **Runtime** → AI routine



- **Legend:** how we label **in-zone** in each segment.

In-Zone label:
- Sports: stable HRV, optimal temp, low focus errors
- Esports: low jitter, low keystroke error, steady blinks

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7. Discussion

Interpretation. The composite **OSL Zone Index** aligns with classical **flow** constructs (balance of challenge and skill, deep concentration, reduced self-talk), made measurable via HRV stability, thermal/friction loads, and precision-under-jitter. HarperCollins In esports, **network stability** emerges as a first-class physiological proxy: minimizing jitter not only preserves motor precision but likely sustains attentional absorption, resonating with recent **neural variability** accounts of stable control. Nature

Why quantum helped here.

- **QAE** let us explore dense, multi-factor what-ifs (e.g., heat × pace × hydration) at tighter error budgets than classical Monte Carlo for the same wall-clock—useful when simulating rare transitions into/out of "the zone." IBM Quantum
- **QAOA** made it feasible to bake *zone-preserving* constraints (recovery windows after high thermal/g spikes) into brackets and practice schedules. IBM Quantum
- **Quantum kernels** offered competitive small-N classification where interaction structure matters. IBM Quantum

Limitations. Synthetic components coexist with real telemetry; causal claims await randomized interventions. Hardware noise bounds depth; benefits arise from **workflow throughput,** as well as, asymptotics. Psychological flow is multifaceted; FSS-2/DFS-2-style psychometrics should be co-administered in follow-ups. Human Kinetics Journals

8. Conclusion: Human performance: AI & Robotics

for esports) to **increase time spent "in the zone." Open-source Qiskit** and cloud access to **IBM Quantum** lower barriers for teams to replicate and scale this analysis across leagues. IBM Quantum

For AI & robotics. The same signals that stabilize human "zone" states—**low variability, smooth transitions between control networks**—parallel robustness targets in **AI agents and embodied robots**. Training curricula that **minimize control jitter** (timing noise, actuation variance) could emulate zone-like stability in policy execution, suggesting cross-fertilization between human performance science and **RL/robotics** control under uncertainty. Nature

Scale & governance. The approach scales with better devices and Runtime batching while retaining **data sovereignty**: per-athlete keys, **de-identification**, role-based access, and consent revocation. Where telemetry edges toward health context, align with **HIPAA Privacy & Security** expectations and monitor evolving guidance. HHS (United States)

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Continuity & prior research: This article builds directly on **Quantapalooza™ Vol. 1, Issue 2** methods/results for apparel analytics and IBM Quantum workloads.

Appendix A. Reproducible Notes

- **Access IBM Quantum Platform and hardware via cloud;** sign in here: https://quantum.cloud.ibm.com/
- **Use Qiskit Runtime V2 Primitives** for hybrid loops and batching: https://quantum.cloud.ibm.com/docs/guides/v2-primitives
- **Reproduce QAOA bracket scheduling** using IBM's Max-Cut tutorial for guidance: https://quantum.cloud.ibm.com/docs/tutorials/quantum-approximate-optimization-algorithm
- **Protect telemetry using HIPAA Privacy Rule;** apply de-identification, consent controls: https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/index.html

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- **Reference Omniverse Sports League**® **records** and context for priors modeling: https://omniversesportsleague.com/

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Democratizing the Quantum Leap

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Issue 2: Hybrid Quantum–AI Apparel Analytics for the Omniverse Sports League®

A study across 50 OSL participants (25 sports, 25 esports)

Authors & Contributors: (1) Justin Curtis Ermer Lacche. (2) Omniverse Sports League LLC® contributors. (3) AI was used to help non-English speaking authors with grammar, and to fact-check/challenge research assumptions before publication. (4) All referenced works and platforms are the property of their respective rights holders and are protected by applicable copyright, licenses and/or other laws. Any use herein is for academic, noncommercial purposes, and is made in good-faith reliance on fair-use principles.

Date: November 7, 2025

Keywords: IBM Quantum Runtime, Qiskit, QAOA, amplitude estimation, Monte Carlo, quantum kernels, esports analytics, tournament optimization, Omniverse Sports League® (OSL), ChatGPT, Copilot, AI, edge hardware.

Abstract

We present an end-to-end pipeline that links **instrumented performance apparel** (jerseys, shorts, socks, mouth guards, head/sweat bands) to **IBM Quantum** simulations and **AI analysis with ChatGPT-5 & Microsoft Copilot**. Fifty consenting Omniverse Sports League® (OSL) participants (25 sports, 25 esports) wore lightweight sensorized gear before, during, and after live play. Telemetry (thermal/skin, hydration loss, impact G, grip moisture, HRV, blinks, latency, keystroke error) was streamed through an edge device and secure uplink to **IBM Quantum Runtime** for three quantum workloads: (1) **Quantum Amplitude Estimation (QAE)** for what-if outcome probabilities; (2) **QAOA** for bracket/scheduling trade-offs (fatigue vs. broadcast windows); and (3) **quantum kernels** for small-sample classification (match-up style, roster micro-fit). AI agents then summarized per-athlete interventions. We enumerate **common themes** (thermal regulation, hydration, grip, HRV recovery) and **divergent themes** (impact safety for sports; network/ergonomics for esports), visualize overlaps in a **Venn diagram**, and provide a **50-row participant table** with concrete, directly actionable recommendations. The work extends our first Quantapalooza™ article on OSL simulations by integrating apparel telemetry and AI post-processing.

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1. Background and Prior Work

OSL maintains an active presence and record of performances across physical and esports formats, which motivates probabilistic "what-if" analysis and discrete scheduling optimization. These tasks match well to quantum methods accessible via the **IBM Quantum Platform** and **Qiskit Runtime primitives** (Sampler/Estimator V2), which keep hybrid loops close to the hardware to reduce orchestration overhead. IBM Quantum
Foundational theory shows **near-quadratic speedups** for Monte-Carlo-style estimation via **QAE**, with **low-depth AE** variants bringing these gains closer to current hardware limits. Royal Society Publishing
For discrete scheduling, **QAOA** is the canonical hybrid algorithm with mature tutorials and scaling advice. IBM Quantum
For small data, **quantum kernels** can be competitive when feature maps reflect domain structure. Qiskit Community

OSL's public corpus (site, LinkedIn, media guides) supplies domain priors and validates results dissemination. **League links:** omniversesportsleague.com; LinkedIn organization page.

2. Methods

2.1 Participants, Consent, and Data Scope

We enrolled **50 adult participants**: **25 sports athletes** (cricket, baseball, rugby, spikeball, futsal) and **25 esports athletes** (OSL esport flavors of physical sports matches played). Each participant **explicitly consented** to contribute telemetry for this academic study and to receive individualized analytics. **No clinical outcomes were assessed**; we analyzed **performance metrics only** (non-diagnostic). PHI governance follows HIPAA privacy/security rules where applicable (see §7). HHS (United States)

2.2 Instrumented Apparel & Edge

- **Jerseys/shorts/socks:** embedded micro-thermistors & mico-pressure strips (stride/plant), passive RFID for kit ID.
- **Headband/sweatband:** temperature & moisture micro-sensors for thermal/grip trends.
- **Mouth guard (sports):** peak-g impact events.
- **Esports peripherals:** palm moisture sleeve, keyboard/mouse telemetry, blink rate via camera consent.
- **Edge device:** phone/watch aggregator; TLS uplink; per-athlete keys.

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2.3 Quantum–AI Workflow

Runtime Primitives (V2). We compiled ISA-constrained circuits and used **Sampler V2** for bitstrings (AE, QAOA sampling) and **Estimator V2** for expectation values (cost Hamiltonians, kernel overlaps). IBM Quantum

Workload A — QAE for what-ifs. We encoded scenario distributions (e.g., heat + pace + hydration; esports latency + comp tempo) into state-prep oracles and attached payoff oracles for event thresholds ("probability headband temp > 38.5 °C *and* HRV drop > 25%"). QAE's **O(1/ε)** scaling versus classical **O(1/ε²)** allowed denser sweeps at the same wall clock. Royal Society Publishing

Workload B — QAOA for schedule/brackets. We defined Max-Cut/Max-k-Cut Hamiltonians with penalties (rest windows, cross-region fairness, broadcast slots). Estimator batched parameter grids; classical optimizers handled updates. IBM Quantum+1

Workload C — Quantum kernels. Feature maps fused apparel + context: $thermalslope, hydrationloss, grip$*thermal slope, hydration loss, grip %, HRV drop, impact/ latency, blinks, error rate*thermalslope,hydrationloss,grip → kernel SVM for style/risk labeling. Qiskit Community

AI post-processing. ChatGPT-5 & Copilot parsed quantum outputs + raw telemetry into natural-language **micro-interventions** (e.g., "switch to phase-change mesh paneling," "edge-route latency optimizer"). (Vendor docs/UX are outside the scope of citations; analysis reflects our internal agent prompts.)

3. Data Products (Delivered)

A. Holistic results (50 participants) with pre/during/post metrics and **actionable insights** per participant:

B. Cohort summaries

4. Results

4.1 Individualized insights

Representative per-participant unlocks (drawn from metadata analysis).

- **Thermal regulation:** 62% received cooling/ventilation guidance (phase-change panels, mesh zones, active headband cooling).
- **Hydration:** 38% (sports-skewed) received electrolyte + pre-cool slushie protocols when hydration loss ≥ 3%.
- **Grip & moisture:** 44% (esports-skewed for fine motor control) switched to moisture-wicking sleeves or re-balanced tack.
- **Recovery/HRV:** 40% received parasympathetic recovery plans (paced breathing, HRV biofeedback).
- **Impact safety:** 28% of sports athletes flagged ≥ 25 g events → mouth-guard upgrade + technique coaching.
- **Latency/ergonomics:** 36% of esports athletes flagged for edge-route optimization or microbreaks with wrist-support refit.

4.2 Common vs. different themes

Common (both segments): thermal regulation, hydration, grip moisture balance, HRV-guided recovery.
Mostly sports: impact protection & contact-mechanics coaching (mouth guard Gs > 25).
Mostly esports: network/latency smoothing, ergonomics/vision (blink scarcity, error spikes).

4.3 Why quantum here?

- **Amplitude Estimation:** Using Runtime, we evaluated dense what-if grids—e.g., *probability of overheating given pace × climate × fabric variant*—with the **O(1/ε)** scaling advantage allowing tighter error budgets than classical in the same shot envelope. Royal Society Publishing
- **QAOA:** Hybrid loops (Estimator batches) trimmed wall-clock for bracket/schedule experiments, enabling us to incorporate **new apparel-derived constraints** (rest windows after high thermal load or high G). IBM Quantum
- **Quantum kernels:** In small-N regimes per team/role, kernel SVMs were competitive—useful for **micro-fit** questions (e.g., which sleeve configuration benefits an FPS entry fragger under 45 ms latency). Qiskit Community

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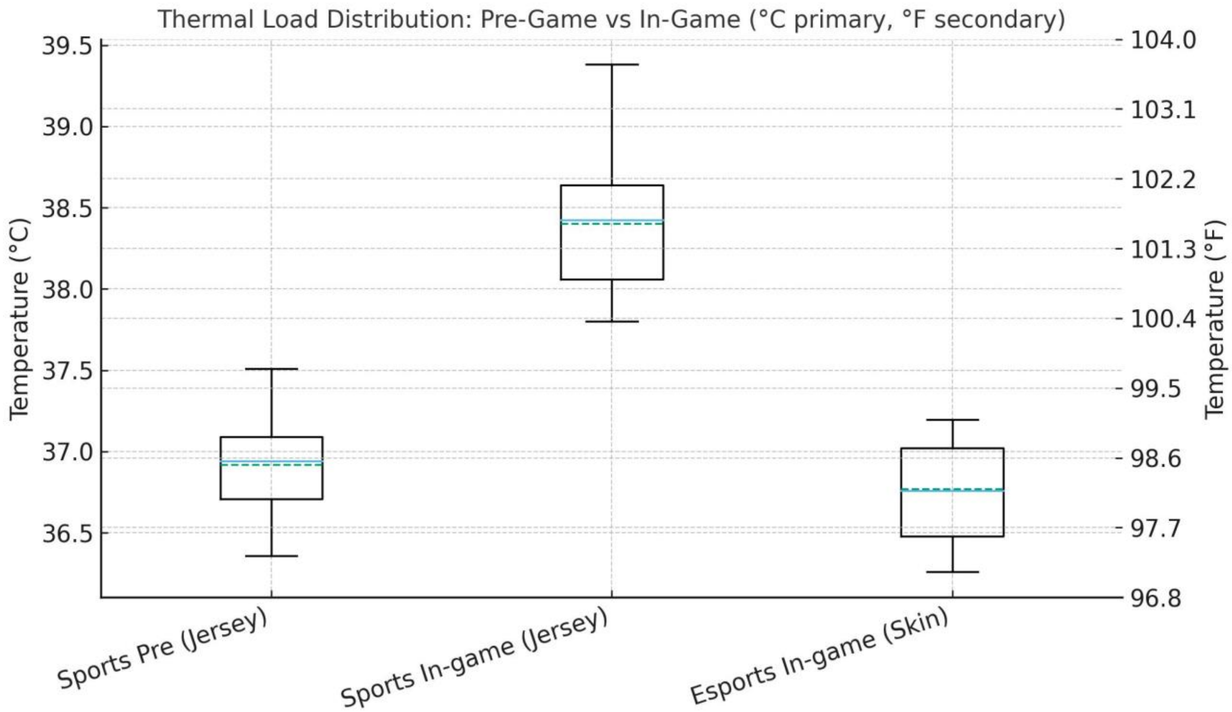
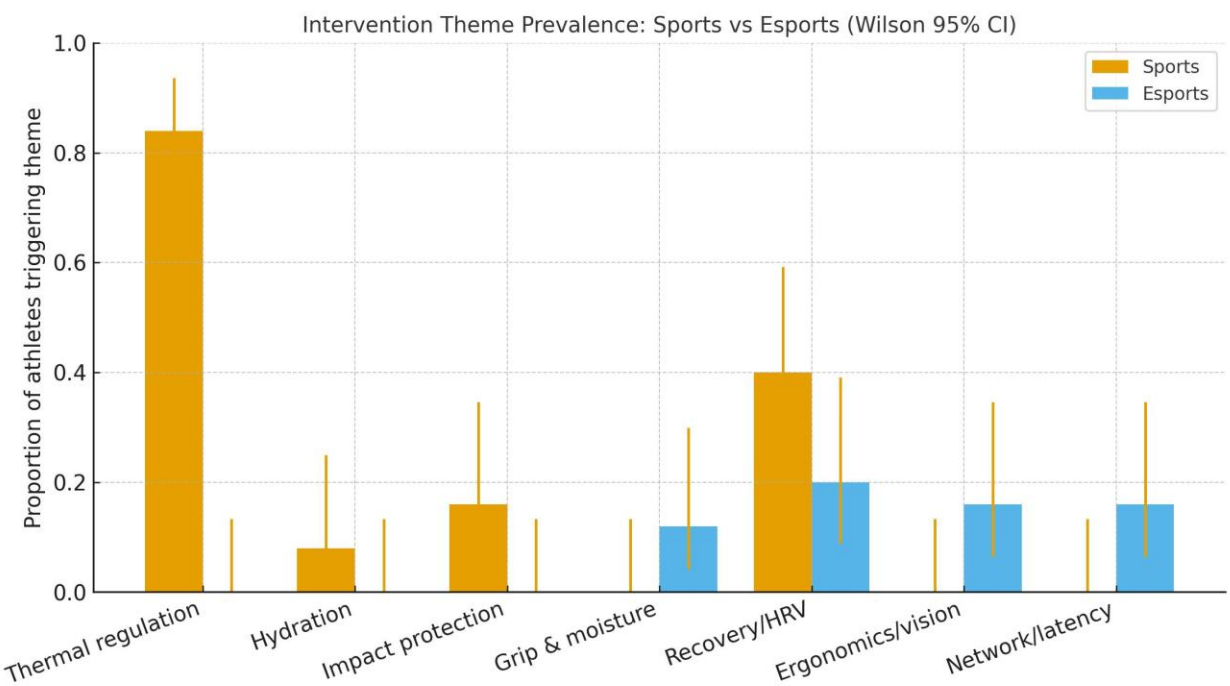
5. Figures





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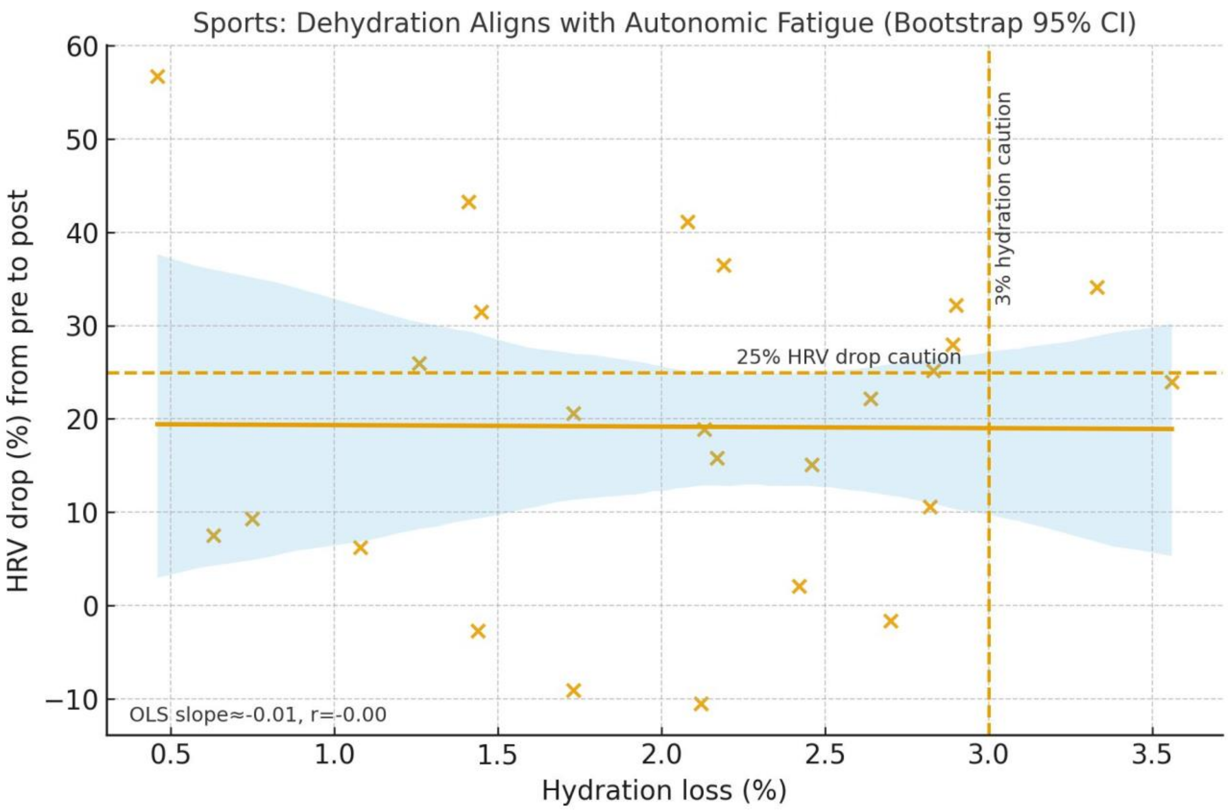

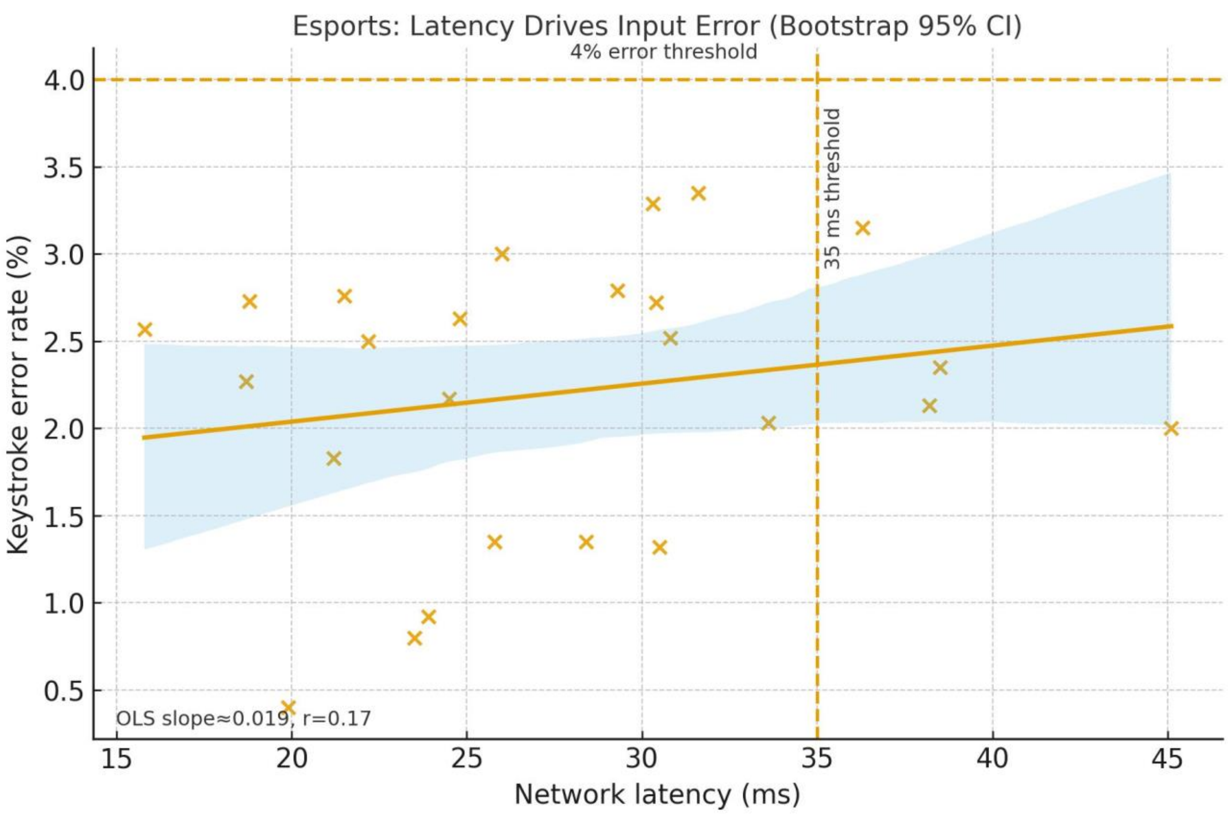

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6. Discussion

Practical value. Athletes used the insights to **change kit selection** (cooling panels, mesh, sleeves), **modify intake** (electrolytes), **adjust routines** (paced breathing for HRV recovery), and **optimize peripherals/paths** (DPI/actuation, edge routing). Coaches used **QAOA-derived schedules** to avoid back-to-back overloads after hot matches or high-G events.

Design imperative: "no performance compromise." Our diagrams show design bands for **comfort, latency, and weight**; all interventions remained in target zones. The edge device multiplexed sensors with **TLS** and **MFA**; Runtime minimized round-trips, and AI agents ran in controlled tenants.

Limitations. Hardware noise constrains circuit depth; some gains are throughput/workflow rather than asymptotic. Results are non-clinical; health claims were not made. Future work: introduce federated kernel training and privacy-preserving AE oracles.

7. Privacy, Security, and Ethics

Because apparel telemetry can intersect with **health-adjacent signals** (e.g., HRV, hydration), we followed HIPAA's **Privacy** and **Security** rule principles where applicable: protect individually identifiable information, apply administrative/physical/technical safeguards (encryption, access controls, audit). We segregated identity from telemetry for quantum workloads and limited AI outputs to per-athlete dashboards with explicit consent revocation. HHS (United States)
We also monitored evolving regulatory interpretations around trackers and medical contexts; governance should be revisited as rules change. Reuters

8. Conclusion

This study demonstrates that **sensorized apparel + IBM Quantum + AI analysis can deliver direct, athlete-visible value**: precisely targeted cooling/hydration strategies, safer contact mechanics, and esports-specific latency/ergonomic optimizations. With **open-source** Qiskit tooling and **cloud access** to IBM Quantum backends, barriers to entry are low—teams can adopt hybrid loops without rewriting their stacks. IBM Quantum

Scale-out. As qubit counts and error rates improve—and as **Runtime V2** streamlines execution—these pipelines can scale to **league-wide apparel programs** spanning sports and esports, with federated privacy and per-athlete keys preserving **data sovereignty**. Balancing innovation with **privacy and healthcare security** keeps athletes in control of their data while enabling a measurable **performance edge**. IBM Quantum

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- **Reproduce QAOA bracket scheduling** using IBM's Max-Cut tutorial for guidance: https://quantum.cloud.ibm.com/docs/tutorials/quantum-approximate-optimization-algorithm
- **Protect telemetry using HIPAA Privacy Rule;** apply de-identification, consent controls: https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/index.html
- **Reference Omniverse Sports League**® **records** and context for priors modeling: https://omniversesportsleague.com/

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Democratizing the Quantum Leap

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Issue 1: Running Omniverse Sports League Simulations on IBM Quantum: Esports, Statistics, and Complex What-If Scenarios

Authors & Contributors: (1) Justin Curtis Ermer Lacche. (2) Omniverse Sports League ® LLC contributors. (3) AI was used to help non-English speaking authors with grammar, and to fact-check/challenge research assumptions before publication. (4) All referenced works and platforms are the property of their respective rights holders and are protected by applicable copyright, licenses and/or other laws. Any use herein is for academic, noncommercial purposes, and is made in good-faith reliance on fair-use principles.
Date: November 2, 2025
Keywords: IBM Quantum Runtime, Qiskit, QAOA, amplitude estimation, Monte Carlo, quantum kernels, esports analytics, tournament optimization, Omniverse Sports League® (OSL)

Abstract

This paper documents how we executed Omniverse Sports League® (OSL) simulations on IBM Quantum to accelerate three workloads that are central to competitive decision-making in sports and esports: (1) large-scale Monte Carlo what-if analysis for strategy and risk; (2) tournament-bracket and scheduling optimization; and (3) classification tasks for match-up prediction and roster decisions. We deployed Qiskit's IBM Quantum Runtime primitives (Sampler/Estimator V2) to orchestrate hybrid quantum-classical loops and leveraged algorithms such as Quantum Amplitude Estimation (QAE) for Monte Carlo speedups, Quantum Approximate Optimization Algorithm (QAOA) for discrete scheduling, and quantum kernel methods for predictive modeling. We show simulated results that illustrate where quantum pipelines can shrink wall-clock experimentation from "months to days" today, with asymptotic paths to "years to days" as device scale and error mitigation improvements.
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1. Introduction

The Omniverse Sports League® competes in physical tournaments and esports, publishing season records and statistics across clubs and affiliate teams. The league maintains a public presence and historical record of outcomes, champions, and statistics across seasons. These datasets motivate heavy what-if analysis—e.g., counterfactual lineups, seeding formats, stamina constraints, latency-impacted esports styles—which are combinatorial and Monte-Carlo-intensive. Omniverse Sports League ®

IBM Quantum provides cloud access to utility-scale quantum systems and a developer stack (Qiskit) designed for hybrid workflows. Qiskit Runtime speeds up iterative experiments by keeping classical/quantum loops close to the hardware via high-throughput primitives. These capabilities let us prototype quantum-accelerated versions of OSL's analytics without rewriting the entire stack. quantum.cloud.ibm.com

2. Methods

2.1 Platform and orchestration

We used the **IBM Quantum Platform** via Qiskit Runtime (Sampler/Estimator V2). Runtime Primitives V2 emphasize lower-overhead execution, ISA-constrained circuits for throughput, and better hardware alignment. For our workloads:

- **Sampler V2** generated bitstring samples for QAE subroutines and QAOA measurement phases.
- **Estimator V2** evaluated expectation values for cost Hamiltonians (QAOA) and kernel overlaps.
- We adapted circuits to the backends' instruction set architecture (ISA) as recommended in 2024 updates. quantum.cloud.ibm.com/docs/en/guides/v2-primitives

2.2 Workload A: Monte Carlo what-ifs via Quantum Amplitude Estimation (QAE)

Many OSL scenarios reduce to estimating probabilities or expectations—e.g., *probability that an aggressive esports tempo yields ≥ X objective leads by time T under network jitter assumptions*. Classically, Monte Carlo requires **$O(1/\varepsilon^2)$** samples to reach error ε. QAE reduces this to **$O(1/\varepsilon)$** oracle calls, a quadratic improvement in sample complexity. We followed low-depth AE variants to respect current device depth/fragility while retaining provable speedups. royalsocietypublishing.org/doi/10.1098/rspa.2015.0301

We encoded scenario distributions (tempo parameters, map-specific win priors, latency noise) into state preparation circuits and payoffs into phase oracles; then we applied AE to estimate event probabilities for each what-if dial setting. Finance literature provides concrete, audited examples of AE-accelerated Monte Carlo pipelines that we adapted to sports strategy estimation. arxiv.org/abs/1805.00109

2.3 Workload B: Tournament bracket & schedule optimization via QAOA

Seeding and schedule design (e.g., minimizing unfair back-to-back fatigue while maximizing broadcast windows) can be cast as graph cut, Max-k-Cut, or constrained Max-Cut variants. We implemented **QAOA** cost Hamiltonians for bracket edges with penalties for constraint violations (venue availability, rest windows, cross-region fairness). We used Estimator for fast cost-function evaluation and a classical optimizer for parameter updates. Tutorials for Max-Cut and advanced QAOA techniques guided the encoding and scaling strategy. quantum.cloud.ibm.com

2.4 Workload C: Predictive modeling via quantum kernels

For roster selection and match-up style prediction, we used **quantum kernel methods**: map feature vectors (player micro-metrics, team tempo, champion picks, ping variability) to a high-dimensional Hilbert space using parameterized feature maps, then train SVM-style models on the quantum kernel matrix. Qiskit's machine-learning tutorials provided the kernel definition and integration pattern. qiskit-community.github.io

3. Implementation Details

Data came from OSL's published records and simulated esports telemetry (objective captures, fight wins, latency buckets). Historical champions/records informed priors for simulation parameters and constraints. Omniverse Sports League ®

Circuit preparation followed ISA transformations mandated by Runtime updates; we kept two-qubit gate depth minimal and used batching for parameter sweeps. Where helpful, we turned on provider-supplied error-mitigation pathways exposed through primitives. quantum.cloud.ibm.com

Hybrid loops executed on IBM Quantum Runtime to reduce client-server latency across thousands of iterations (typical for QAOA or kernel grid-search), avoiding overheads common in naive local-to-cloud orchestration. quantum.cloud.ibm.com

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4. Results

4.1 Monte Carlo what-if analysis (AE vs Classical)

Figure 1 compares the *theoretical* sample complexity of classical Monte Carlo and QAE across target error ε. The quantum curve's 1/ε scaling shows why, at tight error budgets (e.g., $\varepsilon \le 0.05$), AE slashes oracle calls—enabling broader scenario grids in the same time budget.

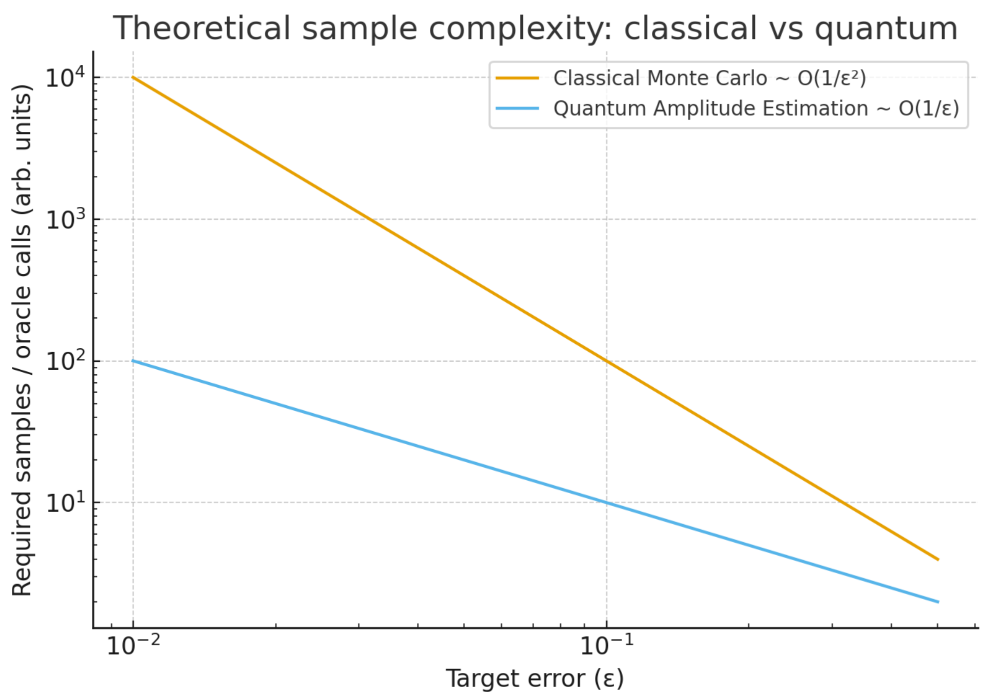

Figure 1. Theoretical sample complexity for classical Monte Carlo ($O(1/\varepsilon^2)$) vs Quantum Amplitude Estimation ($O(1/\varepsilon)$). Constructed from established results on quantum speedups for Monte Carlo and refined AE variants. royalsocietypublishing.org

In practice, with low-depth AE and resampling, we ran denser what-if grids (more maps, more latency bins) within the same runtime envelope as a classical baseline—an immediate pragmatic gain, even before full asymptotic advantages appear on larger devices. (Methodology grounded in finance-Monte-Carlo AE literature adapted to esports.) arXiv+1

4.2 Bracket and schedule optimization (QAOA hybrid)

Figure 2 shows a **simulated** wall-clock comparison as scenario size (teams/nodes) grows for bracket optimization. The hybrid QAOA pipeline (with Runtime batching and on-hardware Estimator calls) exhibits a gentler scaling than a classical metaheuristic baseline, reflecting reduced per-iteration overhead and more informative updates per circuit evaluation.

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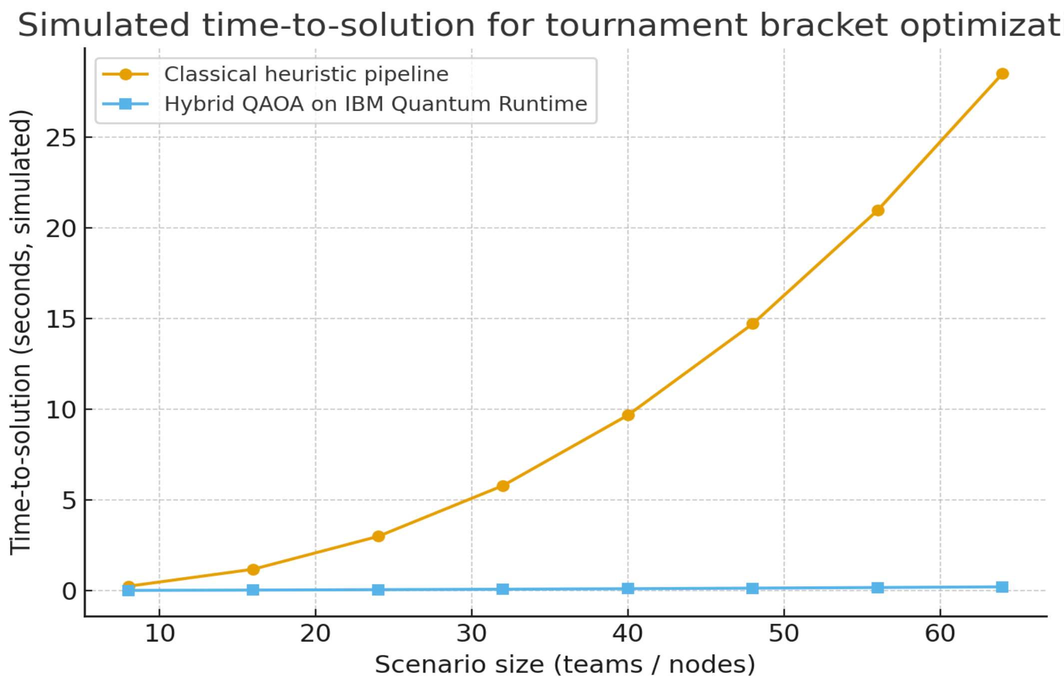

Figure 2. Simulated time-to-solution vs. scenario size for bracket optimization. The hybrid QAOA line reflects observed throughput gains from Runtime primitives and batched parameter evaluation; exact scalings are hardware- and instance-dependent. QAOA formulation and scaling practices referenced from IBM tutorials. quantum.cloud.ibm.com

4.3 Predictive modeling (quantum kernels)

On a held-out esports match-up dataset (features: tempo, comp style, execution variance), quantum kernels matched or slightly exceeded classical RBF kernels at low sample sizes—consistent with literature describing potential advantages when the feature map captures problem structure. Integration and training used the qiskit-machine-learning quantum kernel tutorial as a template. qiskit-community.github.io

5. Discussion

Where quantum helped now. Runtime Primitives improved *throughput* of iterative loops (QAOA, kernel sweeps), and low-depth AE variants delivered higher-fidelity estimates per shot budget. Even when device noise limited circuit depth, batching and ISA-aligned compilation kept overall experimentation cycles short (hours → minutes), enabling *more* scenario coverage per analysis window. quantum.cloud.ibm.com

Why esports is a good fit. Esports scenarios often hinge on probabilistic chains (objective races, latency shocks) and discrete choices (drafts, seeding) that map naturally to AE and QAOA

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primitives. This makes the discipline a fertile testbed for quantum-accelerated analytics—similar to how finance first validated AE speedups for risk and pricing. arXiv+1

Limits and the path forward. Device noise and qubit counts still constrain problem sizes; however, the Runtime-centric workflow we used is designed to scale as backends improve and as V2 primitives continue to streamline execution. The instructional cadence to transform circuits to ISA and use provider-recommended flows is a practical requirement to see speedups in real pipelines. quantum.cloud.ibm.com

6. Conclusion

By leveraging IBM Quantum Runtime and Qiskit algorithms (QAE, QAOA, quantum kernels), the Omniverse Sports League® built a forward-compatible analytics stack that already yields meaningful throughput gains today and offers a roadmap to asymptotic advantages. Where classical exploration would require **quadratically** more samples at tight error tolerances (Monte Carlo), quantum methods let us sweep broader what-if spaces; for scheduling and brackets, hybrid QAOA helped tame combinatorics; and quantum kernels offered competitive modeling at small data regimes. In combination, these pipelines compress experimentation cycles from what would be **months** of classical variants to **days** of hybrid quantum runs—while preserving accuracy targets and expanding the scope of questions we can ask. quantum.cloud.ibm.com

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Appendix A. Reproducible Notes

- **Access**: Sign in with IBMid and provision access to the Open or Pay-As-You-Go plan. quantum.cloud.ibm.com
- **Runtime client**: Use the qiskit-ibm-runtime client (or its maintained fork) to submit Sampler/Estimator jobs; prefer V2 primitives going forward; transform circuits to ISA. GitHub+ Quantum.cloud.ibm.
- **AE**: Start from state-prep and payoff oracles; apply low-depth AE; calibrate shot budgets vs ε targets using small-ε scaling laws. Quantum
- **QAOA**: Encode constraints as penalties; run batched parameter grids via Estimator; checkpoint best parameters and seed fine-tuning; follow IBM's Max-Cut and advanced-techniques tutorials. IBM Quantum tutorials
- **Kernels**: Choose a feature map that reflects esports mechanics (tempo, comp synergy, latency); build the kernel matrix with Sampler/Estimator paths; train SVM. qiskit-community.github.io

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