Vars & Controls Reference

This reference summarises every configurable variable (`GameConfig` and `PerformanceFlags`), every CLI flag, and each control-panel slider. For each item you'll find a short description plus what happens when you push the value up or down (or enable/disable it).

GameConfig Variables

Grid & Timing

Setting	Purpose	Higher / Enabled	Lower / Disabled
`Nx`	Horizontal simulation cells; sets course resolution.	Finer spatial detail but heavier CPU/GPU load.	Coarser geometry with faster simulation but chunkier visuals.
`Ny`	Vertical simulation cells; pairs with `Nx`.	More vertical detail at the cost of performance.	Less detail and smoother performance.
`dx`	Physical width per grid cell.	Enlarges the simulated course and slows propagation.	Shrinks the virtual course and speeds up motion.
`dy`	Physical height per grid cell.	Taller effective arena; slower vertical dynamics.	Compresses vertical scale; faster vertical motion.
`dt`	Base physics timestep.	Larger steps increase speed but risk instability.	Smaller steps stabilise the solver but need more iterations.
`steps_per_shot`	Nominal simulation steps per swing.	Longer ball lifetime before auto-reset.	Shots end sooner; less time to observe behaviour.
`max_steps_per_shot`	Hard ceiling on steps.	Allows extended rallies at higher cost.	Forces resets earlier, guarding performance.
`draw_every`	Frames skipped between renders.	Fewer redraws → faster but choppier animation.	More redraws → smoother visuals but slower.

Potentials & Obstacles

Setting	Purpose	Higher / Enabled	Lower / Disabled
`V_edge`	Potential wall at arena boundary.	Stronger reflection/containment; harder to leak out.	Softer edges; waves creep outward more.
`V_wall`	Potential for central barriers.	Tougher barrier, tighter quantum tunnelling.	Easier passage through walls/slots.
`single_wall_width`	Width (cells) for single barrier map.	Broader wall, increasing obstruction.	Slimmer wall that's easier to bypass.
`single_wall_thickness_factor`	Multiplier for wall width.	Thickens obstacles proportionally.	Thinner walls, larger openings.
`slit_height`	Aperture height for slit maps.	Wider slit allowing more vertical spread.	Narrow slit causing stronger diffraction.
`slit_sep`	Distance between slits.	Greater spacing, widening interference pattern.	Closer slits, tighter interference fringes.
`center_wall_width`	Thickness of the central plate.	Heavier obstruction between slits.	Lighter obstruction, easier passage.

Hole & Course Layout

Setting	Purpose	Higher / Enabled	Lower / Disabled
`hole_r`	Radius of the hole capture zone.	Easier to sink shots; larger target.	Harder to score; smaller capture area.

Setting	Purpose	Higher / Enabled	Lower / Disabled
`ball_start_x_frac`	Initial ball X as fraction of width.	Starts closer to the hole/right edge.	Starts nearer the left tee.

Boundaries & Absorption

Setting	Purpose	Higher / Enabled	Lower / Disabled
`absorb_width`	Absorbing strip width at edges.	Wider damping zone killing reflections.	Narrow strip; more boundary bounce-back.
`absorb_strength`	Strength of absorbing border.	Faster decay of outbound waves.	Weaker absorption, more ringing.
`edge_boundary`	Boundary condition (reflect/absorb).	`reflect` keeps energy in bounds.	`absorb` drains energy at the walls.
`edge_reflect_cells`	Thickness of reflective layer.	Increased buffer preventing leakage.	Thinner layer; easier to escape.
`edge_reflect_height`	Potential height for reflecting edge.	Strong push-back at border.	Softer reflection.

Measurement & Sinking

Setting	Purpose	Higher / Enabled	Lower / Disabled
`quantum_measure`	Auto-collapse of the wave when triggers fire.	Enables measurement events for hybrid modes.	Disables automatic measurements.
`measure_gamma`	Sharpness of measurement sampling.	Collapses tightly around peaks.	Produces broader, fuzzier measurements.
`sink_rule`	Method used to detect a hole.	`prob_threshold` checks probability mass.	`measurement` waits for explicit collapse hits.
`sink_prob_threshold`	Probability needed to count as holed.	Requires more certainty to score.	Easier to register makes.
`measurement_sink_min_prob`	Minimum probability considered for measurement sink.	Filters out tiny probabilities.	Accepts even faint measurement hits.

Controls & Logging

Setting	Purpose	Higher / Enabled	Lower / Disabled
`enable_mouse_swing`	Allows mouse-based swings alongside tracker.	Enables desktop control.	Tracker-only input.
`multiple_shots`	Keeps the ball where it stopped until holed.	Sequential shot challenges.	Ball resets after each attempt.
`log_data`	Records tracker telemetry.	Writes periodic data to `vr_debug_log.txt`.	Suppresses logging overhead.

Tunnelling & Swing Mapping

Setting	Purpose	Higher / Enabled	Lower / Disabled
`kmin_frac`	Minimum k-vector fraction for slow swings.	Raises baseline energy, boosting soft taps.	Allows gentler swings to travel less.
`kmax_frac`	Maximum k-vector fraction.	Higher cap allows harder hits before aliasing.	Caps extreme swings sooner.
`tunneling_speed_weight`	Influence of swing speed on tunnelling.	Speed has stronger impact on barrier penetration.	Thickness dominates tunnelling behaviour.

Setting	Purpose	Higher / Enabled	Lower / Disabled
`barrier_thickness_power`	Exponent scaling wall strength.	Thick barriers become dramatically harder.	Wall strength grows more gently with thickness.
`tunneling_thickness_weight`	Weight of thickness in tunnelling mix.	Wall geometry heavily influences outcome.	Speed dominates tunnelling probability.

Wave Initialisation

Setting	Purpose	Higher / Enabled	Lower / Disabled
`wave_initial_profile`	Starting wave shape (`packet` or `front`).	Choose `front` for planar launches.	Choose `packet` for localized starter waves.
`wavefront_transition_len`	Smoothing length when using `front`.	Softer transition from front to rest.	Sharper front edge, more ringing.
`wavefront_sigma_y`	Vertical spread of initial wave.	Broader vertical coverage.	Narrow beam at launch.
`wavefront_sigma_forward`	Forward decay for wavefront profile.	Longer wake before decay.	Shorter tail, more localized start.

Shot Termination & Friction

Setting	Purpose	Higher / Enabled	Lower / Disabled
`shot_stop_mode`	Decide between time-based or friction-based cutoff.	`friction` stops when speed drops sufficiently.	`time` stops after the step quota.
`shot_friction_linear`	Linear drag term.	Faster slowing even at gentle speeds.	Lets the ball roll longer.
`shot_friction_quadratic`	Quadratic drag term.	Hits fast swings harder.	Preserves high-speed motion.
`shot_friction_cubic`	High-order drag term.	Strong braking at very high velocity.	Less braking on powerful hits.
`shot_friction_min_scale`	Lower bound for combined friction multiplier.	Prevents friction from getting too low.	Allows shots to coast more when slowed.

Probability Boosting

Setting	Purpose	Higher / Enabled	Lower / Disabled
`boost_hole_probability`	Toggles probability-boost mechanic.	Hole probability increases after misses.	No artificial bias toward sinking.
`boost_hole_probability_factor`	Base boost amount.	Large constant nudge toward the cup.	Minimal assist from the booster.
`boost_hole_probability_increment`	Per-measurement boost.	Booster ramps up quickly on repeated tries.	Slower ramp that feels more natural.
`boost_hole_probability_autoincrement_on_measure`	Auto-bump boost when measurements happen.	Guarantees gradual assistance.	Keeps boost fixed unless manually adjusted.

Visibility & Rendering

Setting	Purpose	Higher / Enabled	Lower / Disabled
`PlotBall`	Draw the classical ball.	Ball remains visible.	Hides the ball marker.
`PlotWavePackage`	Draw the quantum wave heatmap.	Shows quantum field.	Removes wave overlay (classic-only look).

Setting	Purpose	Higher / Enabled	Lower / Disabled
`smooth_passes`	Extra blur passes on the wave.	Softer visuals, slight cost.	Sharper but noisier rendering.
`vis_interpolation`	Matplotlib interpolation mode.	`bilinear` / `bicubic` smooth the texture.	`nearest` keeps pixelated look (faster).
`display_downsample_factor`	Downsample factor for display pipeline.	Smaller render buffer, faster but softer.	Higher fidelity at cost of speed.
`low_dpi_value`	DPI for low-DPI mode.	Larger numbers make UI crisper.	Smaller numbers lighten load but blur UI.
`target_fps`	Desired redraw rate.	Aims for smoother animation, more CPU.	Frees CPU, may look choppier.
`debounce_ms`	Mouse event debounce.	Prevents double-firing at cost of responsiveness.	Snappier controls but risk of double hits.
`path_decimation_stride`	Sampling stride for overlay paths.	Coarser path that renders faster.	Denser path, cleaner trails but slower.
`overlay_every`	Frames between overlay updates.	Less frequent overlay refresh, saving time.	Overlay updates every frame for maximum fidelity.

Motion & Swing Scaling

Setting	Purpose	Higher / Enabled	Lower / Disabled
`movement_speed_scale`	Multiplier applied after a shot.	Ball and wave travel faster across the grid.	Slower movement for precision play.
`swing_power_scale`	Converts tracker speed to shot energy.	Smaller wrist motion produces big shots.	Requires stronger swings to launch.
`impact_min_speed`	Minimum tracker speed to trigger a hit.	Filters weak swings to reduce false hits.	Allows gentle taps to register.

Tracker Integration

Setting	Purpose	Higher / Enabled	Lower / Disabled
`use_tracker`	Toggles LED putter tracking.	Tracker drives swings.	Mouse-only play.
`tracker_speed_scale`	Converts tracker velocity to in-game power.	Faster ball for the same real swing.	Dampened in-game response.
`tracker_threshold`	Brightness threshold for LED detection.	Ignores dim background noise.	More sensitive but can mis-detect lights.
`tracker_length_scale`	Scales overlay putter length.	Longer virtual club for the same LED spacing.	Shorter overlay to match smaller rigs.
`tracker_thickness_scale`	Scales overlay putter width.	Thicker virtual paddle.	Slimmer overlay.
`tracker_min_span_px`	Minimum LED spacing to consider valid.	Rejects cramped LED detections.	Accepts shorter tracked spans.
`tracker_overlay_thickness_px`	Baseline overlay thickness in pixels.	Visually thicker putter.	Thinner overlay.
racker_coord_margin	Extra padding when clamping tracker coordinates.	Lets overlay drift slightly beyond borders to avoid lag.	Strict clamp that snaps the putter inside the board.
`tracker_area_limit`	Maximum allowed overlay area before suppression.	Larger puts allowed before hits suppressed.	Tight limit used to avoid covering the hole.
`tracker_debug_window`	Show OpenCV debug window.	Visual feedback while tracking.	Keeps desktop clutter-free.

Setting	Purpose	Higher / Enabled	Lower / Disabled
`tracker_crop_x1/track_crop_x2/...`	Manual ROI for the camera frame.	Smaller ROI speeds processing, must include LEDs.	Leave zero for full-frame capture.
`tracker_calibration_path`	Path to course calibration file.	Loads specific homography.	Auto-search default locations.
`tracker_auto_scale`	Learns scale/offset from observed motion.	Auto-calibrates when no homography exists.	Relies solely on provided calibration.
`tracker_max_span_px`	Max LED span before rejecting frame.	Allows very wide stance clubs to register.	Rejects frames when LEDs separate too far.
`tracker_coord_margin`	Extra margin when clamping tracker coordinates.	Lets overlay drift slightly past borders, reducing drift.	Tighter clamp that snaps overlay inside the board.

Timing & Playback

Setting	Purpose	Higher / Enabled	Lower / Disabled
`shot_time_limit`	Time quota per shot (seconds).	Allows drawn-out rallies.	Ends a shot sooner.
`video_playback_speed`	Playback speed multiplier for recordings.	Faster review of recorded shots.	Slower, more detailed review.

Map & Resolution

Setting	Purpose	Higher / Enabled	Lower / Disabled
`map_kind`	Starting course layout.	Switch to obstacle-heavy courses.	Choose simplified layouts.
`res_scale`	Multiplier for simulation grid size.	High-res simulation with extra detail.	Lower resolution for speed.

Swing & Visual Constants

Setting	Purpose	Higher / Enabled	Lower / Disabled
`ball_r`	Ball radius for drawing/collision.	Larger ball gives visual emphasis.	Smaller ball for delicate visuals.
`indicator_r`	Aim indicator radius.	Easier to track pointer.	Minimal indicator for precision.
`sigma0`	Default wave packet spread.	Broader initial wave.	Tighter wave focus.
`perf_sigma0`	Reduced spread used in performance modes.	Slightly bigger fallback packet.	Tighter fallback for speed runs.
`perf_steps_factor`	Step reduction ratio in performance mode.	Keeps more physics steps while still accelerating.	Heavier trimming for FPS recovery.

Background & Overlay

Setting	Purpose	Higher / Enabled	Lower / Disabled
`background_image_path`	Path to background texture.	Loads the specified image.	Default black backdrop.
`background_image_alpha`	Opacity of the background image.	More visible texture.	More of the default dark background.
`wave_overlay_alpha`	Opacity of wave heatmap.	Stronger overlay, hides background.	Fainter overlay, lets background shine through.

PerformanceFlags

Flag	Purpose	Higher / Enabled	Lower / Disabled
`blitting`	Reuses background buffers in Matplotlib.	Faster redraws, especially for static backgrounds.	Safer when artist count changes often.
`display_downsample`	Downsample images before display.	Reduces bandwidth to UI; blurrier picture.	Highest fidelity but heavier load.
`gpu_viz`	Uses GPU pipeline for visuals.	Offloads drawing to GPU when available.	CPU-only rendering.
`low_dpi`	Use reduced DPI for the window.	Lighter on older GPUs/monitors.	Full native DPI.
`inplace_step`	Reuse arrays in physics solver.	Less memory churn, faster.	Safer when debugging modifications.
`adaptive_draw`	Skip frames adaptively when busy.	Keeps UI responsive under load.	Renders every frame regardless of cost.
`path_decimation`	Simplify stroke paths before drawing.	Less detail but faster overlay.	Full detail for precise review.
`event_debounce`	Debounce Matplotlib events.	Prevents double-firing but adds delay.	Maximum responsiveness.
`fast_blur`	Use faster (approximate) blur kernels.	Saves CPU with slight visual trade-off.	Highest-quality blur at extra cost.
`pixel_upscale`	Fake pixel-art scaling for wave texture.	Crisp retro look and less interpolation.	Smooth interpolation between cells.

Command-Line Flags

Flag	Purpose	Higher / Enabled	Lower / Disabled
`--map`	Picks the starting obstacle layout.	Choose complex maps for extra challenge.	Choose simpler layouts for quick demos.
`--mode`	Sets initial visualization mode.	`quantum` / `mixed` show wave effects.	`classical` keeps things familiar.
`--course`	Launches a scripted multi-stage course.	Jump straight into guided scenarios.	Free-play mode.
`--wave-profile`	Chooses starting wavefront shape.	`front` for wall of energy.	`packet` for localized launch.
`--stop-mode`	Select shot termination rule.	`friction` ends when motion stops.	`time` uses fixed duration.
`--wall-thickness`	Scales central wall thickness.	Narrow the channel; harder shots.	Wider gaps; easier tunnelling.
`--movement-speed`	Overrides `movement_speed_scale`.	Speeds traversal between collisions.	Slows the overall gameplay pace.
`--shot-time`	Overrides `shot_time_limit`.	Longer shot life; marathon rallies.	Shorter attempts; quick resets.
`--sink-threshold`	Sets sink probability threshold.	Requires higher certainty before sinking.	Easier to score with lower bar.
`--boost-increment`	Overrides per-measurement boost.	Booster ramps up faster.	Subtle assistance.
`--boost-factor`	Overrides baseline boost.	Higher constant bias toward the hole.	Minimal or no bias.
`--mouse-swing`	Forces mouse control on.	Desktop swings always available.	Tracker takes priority when present.
	Keeps ball position between	Campaign-style chained attempts.	Classic reset after each

Flag	Purpose	Higher / Enabled	Lower / Disabled
`--multiple-shots`	turns.		stroke.
`--log-data`	Enables tracker telemetry logging.	Generates detailed vr-debug logs.	No logging overhead.
`--background-path`	Loads a specific background image.	Supplies a custom texture.	Falls back to black backdrop.
–performance-increase	Enables the experimental performance toolkit.	Activates GPU preference, reduced resolution, cached operators.	Keeps the default feature set.
–fast-mode-paraxial	Optional arcade/paraxial propagation (perf-mode only).	Trades accuracy for additional speed-ups.	Ignores the flag and uses standard propagation.
`--no-tracker-auto-scale`	Disables automatic tracker scaling.	Honors provided calibration entirely.	Lets tracker self-calibrate.
`--tracker-max-span`	Sets max LED separation before rejecting.	Accepts wide stances.	Enforces compact club movement.
`--config-panel`	Opens slider control panel on start.	Immediate access to runtime tuning.	Panel stays hidden unless toggled.
`--no-control-panel`	Keeps control panel hidden.	Prevents accidental panel popups.	Panel can still be opened manually.
`--quantum-measure`	Turns automatic quantum measurements on.	Hybrids collapse automatically.	Requires manual triggering.
`--no-quantum-measure`	Forces measurements off.	Purely classical/visual play.	Automatic collapse stays available.
`--measurement-gamma`	Adjusts measurement sharpness.	Tighter collapses around peaks.	Broader sampling.
`--sink-rule`	Chooses scoring rule.	`measurement` waits for collapse hits.	`prob_threshold` uses probability mass.
`--edge-boundary`	Chooses boundary type.	`reflect` keeps energy inside.	`absorb` drains it away.
`--max-steps-per-shot`	Overrides `max_steps_per_shot`.	Longer computations per stroke.	Early resets to guard frame rate.
`--perf-profile`	Applies performance presets.	`fast` trades fidelity for speed.	`quality` keeps visuals pristine.
`--blit` / `--no-blit`	Force-enable/disable blitting.	Speeds up rendering when stable.	Safer when artists change frequently.
`--gpu-viz` / `--no-gpu-viz`	Toggle GPU-backed visuals.	Attempt GPU acceleration.	Stay on CPU for compatibility.
`--target-fps`	Override target FPS.	Smoother animation target.	Lower demand for weak hardware.
`--draw-every`	Override draw skip factor.	Skip more frames to boost speed.	Draw every frame for smoothness.
`--res-scale`	Rescale grid resolution.	Higher detail, slower sim.	Lower detail, faster sim.
`--vr` / `--no-vr`	Toggle tracker swing input globally.	Fully VR putter control.	Mouse-only control.
`--display-tracker` / `--no-display-tracker`	Show/hide tracker debug window.	Visual feedback while tuning.	Cleaner desktop.
`--calibrate-course`	Run manual corner picker.	Captures fresh homography.	Skips manual calibration.
`--calibrate-course-led`	Run LED auto-calibration.	Auto-detect LEDs to build homography.	Relies on existing calibration.

Flag	Purpose	Higher / Enabled	Lower / Disabled
`--calibration-path`	Specify calibration file.	Explicit file loaded each run.	Auto-discover fallback paths.
`--skip-calibration-preview`	Skip post-calibration preview window.	Faster startup; no visual check.	Preview ensures alignment.
`--record-video`	Render scripted demo to MP4.	Generates showcase video (optional path).	Launch interactive app.
`--record-output`	Path for `--record-video` output.	Directs MP4 to chosen file.	Uses default demo filename.
`--headless`	Use non-interactive backend.	Run without opening a GUI (useful for CI).	GUI launches as normal.
`--boost-hole` / `--no-boost-hole`	Toggle probability boosting.	Enables auto-assist after misses.	Keeps strict physics.
`--dump-config`	Print resolved `GameConfig`.	Useful for logging/debugging.	Keeps console quieter.
`--backend`	Force physics backend (`auto`, `cpu`, `gpu`).	Choose GPU for acceleration.	Choose CPU for compatibility.

Control Panel Sliders

Slider	Purpose	Increase	Decrease
`Boost Increment`	Adjusts `boost_hole_probability_increment`.	Booster ramps up faster after each measurement.	Booster grows slowly, keeping play fair.
`Move Speed`	Tweak `movement_speed_scale`.	Ball and wave travel farther per shot.	Shots advance gently for precision.
`Shot Time`	Modifies `shot_time_limit`.	Shots stay alive longer before reset.	Shots end sooner to keep pace brisk.
`Wall Thickness`	Adjusts `single_wall_thickness_factor`.	Walls bulk up, narrowing channels.	Wider openings through the barrier.
`Tracker Threshold`	Sets `tracker_threshold`.	Ignores dim speckles; needs brighter LEDs.	Accepts dim LEDs but risks noise.
`Tracker Speed`	Controls `tracker_speed_scale`.	Amplifies swing-to-shot power mapping.	Softens swing impact.
`Tracker Max Area`	Sets `tracker_area_limit`.	Allows large overlay area before suppressing hits.	Prevents swings when the club covers too much of the board.

Use this sheet as a quick cheat sheet whenever you fine-tune the simulator, script launches, or explain the UI to newcomers. Feel free to extend it with your own project-specific defaults or presets.***

Performance Mode Controls

Setting	Purpose	Higher / Enabled	Lower / Disabled
performance_increase	Master performance toggle.	Enables the full optimisation suite.	Uses the original high-fidelity pipeline.
ast_mode_paraxial	Optional paraxial propagator.	Switches to an arcade-style approximation.	Keeps the standard split-step solver.
performance_theta	Phase-budget safety factor (radians).	Permits larger stable timesteps.	Keeps timesteps conservative.
performance_dt_tolerance	Tolerance before rebuilding exponent operators.	Reuses cached operators longer.	Rebuilds more often for accuracy.

Setting	Purpose	Higher / Enabled	Lower / Disabled
performance_friction_bins	LUT bins for friction-speed scaling.	Smoother interpolation of exponent pairs.	Coarser quantisation, less memory.
performance_res_scale	Default resolution scale when perf mode engages.	Stronger downscale for speed.	Retains higher fidelity.
performance_display_downsample	Minimum display downsample factor.	Smaller buffers, quicker rendering.	Full-resolution frames.
performance_smooth_passes	Blur passes during perf mode.	Adds polish when needed.	Zero for maximum performance.
performance_draw_every	Baseline draw stride under perf mode.	Skips more frames to stabilise FPS.	Renders more often for richer detail.
performance_drift_threshold	Density threshold to allow burst drift.	Burst drift triggers less often.	Aggressive acceleration far from obstacles.
performance_max_drift_steps	Cap on burst-drift length.	Longer bursts per FFT pair.	Short bursts, closer to baseline feel.
performance_enable_window	Moving-window optimiser switch.	Attempts cropped evolution when supported.	Sticks to full-grid evolution.
performance_window_margin	Safety padding for the moving window.	Wider margin reduces clipping risk.	Tighter margin for maximum speed-up.