TEST SUITE

Project Name: 2B or not 2B
Team Name: FLMA8
GitHub Repository: https://github.com/sareensabra/2026-NVIDIA

The validation follows a bottom-up strategy: low-level numerical components are verified first, followed by local optimization, population-based coordination, and finally the quantum seeding layer. This structure ensures that failures in the integrated workflow can be attributed to algorithmic limitations rather than implementation errors.

1. FFT Autocorrelation Validation

These tests validate the Fast Fourier Transform (FFT) implementation used to compute LABS autocorrelation energy. The suite compares FFT results against exact naive O(N^2) calculations on small sequences, verifies correctness across multiple problem sizes (N = 8, 16, 32, 64), and benchmarks performance at N = 256 to confirm the expected O(N log N) scaling. This component is critical because LABS optimization requires evaluating thousands of candidate sequences; replacing the naive quadratic method with FFT provides approximately a 131x speedup at N = 256. The tests ensure that this acceleration does not compromise numerical accuracy.

2. Tabu Search Validation

The tabu search tests verify the correctness of the local optimization engine and its memory mechanism. Specifically, they confirm that moves are correctly added to and checked against the tabu list, that tabu tenure expiration allows previously forbidden moves to become admissible again, and that local search consistently reduces energy (for example, from 75 to 23 in controlled cases). These validations are essential because tabu search prevents cycling and enables effective exploration of the solution space, balancing short-term exploitation with long-term diversification.

3. Memetic Tabu Search (MTS) Validation

The MTS tests evaluate the full population-based framework that combines evolutionary operators with tabu-guided local refinement. The suite confirms that the algorithm runs end-to-end without errors, demonstrates that MTS significantly outperforms random sampling (average energy about 5 versus about 48.8), and verifies that quantum-generated initial sequences integrate correctly into the classical population. These checks establish that MTS functions as an effective global coordinator and that quantum seeds are properly incorporated into the hybrid workflow.

4. Quantum VQE Validation

The VQE tests validate the quantum component responsible for generating high-quality seed sequences. They ensure that circuits execute correctly and return valid bitstrings, that the hardware-efficient ansatz (RY, RZ, and CX gates) is constructed as intended, and that sampled bitstrings convert cleanly into {-1, +1} sequences for classical processing. Additional tests confirm that VQE optimization reduces energy during training, that the custom Hamiltonian's 2-body and 4-body terms correctly encode the LABS objective, that kernel recompilation handles changing qubit counts, and that CUDA-Q sampling results convert reliably into Python data structures. Together, these tests verify quantum execution, cost-function correctness, optimizer convergence, and quantum-classical interface stability.