Quantum-induced basin sampling in frustrated Ising landscapes

EuroHPC Quantum Access Pilot application

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The application package

01 Scientific case and team

Six-month academic proposal targeting RUBY

02 Technical plan and resource request

Software, scaling, hybrid workflow and integration support

03 Feasibility proof and declarations

Executed emulator results, reproducible code and eligibility

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The scientific question

How does quantum evolution populate competing low-energy basins?

Frustration creates competing local minima.

A basin groups configurations that descend to the same minimum.

We compare solution quality, diversity and basin probabilities.

The quantum–classical experiment

01 **Geometry and screening**

Atom positions define the interactions.

02 **Quantum evolution and measurement**

Rise, sweep, hold, freeze, then sample bitstrings.

03 **Common basin assignment**

The same deterministic descent maps all samples.

04 **Classical comparison**

Compare basin probabilities, quality and diversity.

What the feasibility proof demonstrates

9 atoms

End-to-end workflow

12 atoms

Verified coarse emulator scan

31 local minima, including 6 low-energy basins

Selected point: 2 replicates × 500 quantum shots

Ideal emulator evidence. Physical RUBY execution remains ahead.

Quality and diversity at the selected point

Sampler	Low-energy probability	Effective basin count
Quantum	**65.8%**	**8.846**
Uniform random	35.2%	19.389
Simulated annealing	65.2%	8.999
Parallel tempering	95.4%	3.784

Quantum closely matches simulated annealing here.

Two-replicate means from ideal emulation. No quantum advantage established.

The requested allocation

50

QPU hours on RUBY

For a period of 6 months.

The six-month project: next steps

Qualify the deployed environment

Device limits, Hosting Entity emulator and submission interfaces

Run selected RUBY experiments

Staged scaling, repeated measurements and noise controls

Evaluate basin-sampling behavior

Reproducible distributions and comparisons with classical methods