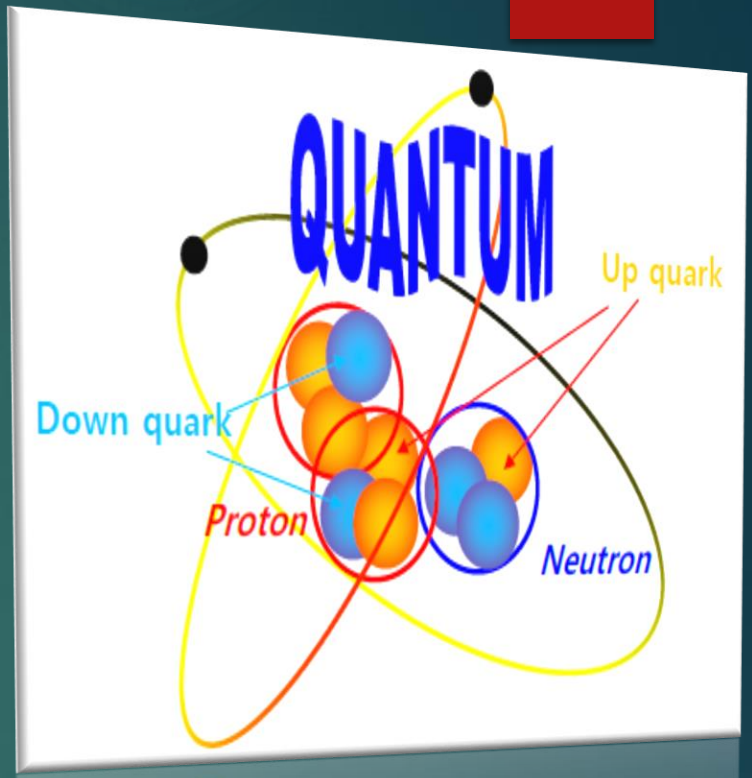
The Korean Nuclear Society Spring Meeting, Changwon, Korea, Dec. 17-18, 2020

Revolutionary Implications of Nuclear Waste Disposals by Quantum Entanglement: Prospective Frontier of Nuclear Engineering by the U.S. National Quantum Computing Initiative



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I. Introduction

- The quantum mechanics is applied to our lives from the invisible subatomic world to the information and knowledge in the real-life of humans.
- The theoretical implications could be the consequences as the communications and simulations purposing job creations and industrial promotions.
- The abundant goals in the quantum regions would be manipulated including the tiny nuclei which can be informed by the quantum computation.

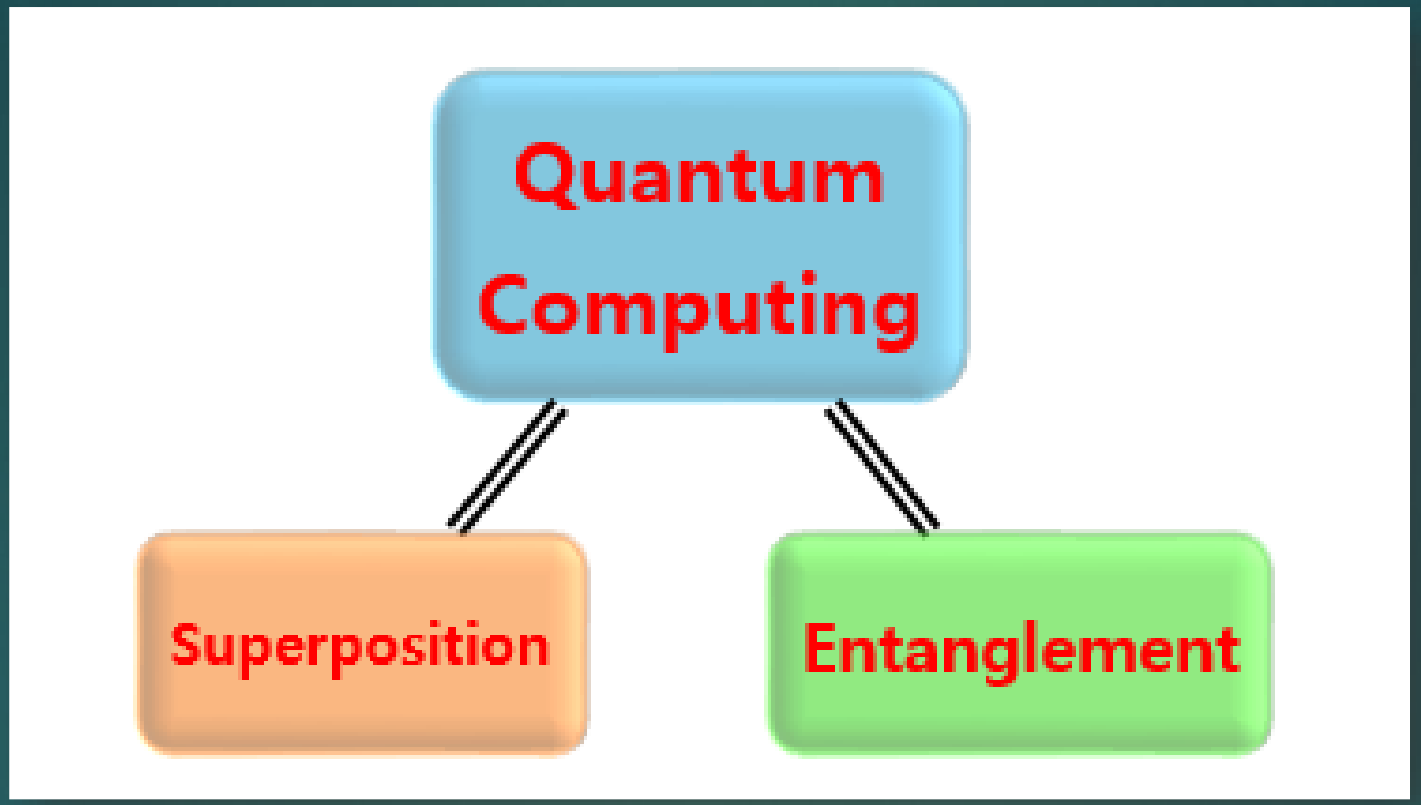


Fig. 1. Description of quantum computing.

2. Methods

- Table 1 is the list of selected physical implementations in quantum [8] where there is quantum information as the spin, charge, or polarization with the quantum descriptions.
- For the graphical feature, Fig. 2 shows the Bloch sphere for Qubit [8] in which the quantum numbers are described by the Bloch sphere.

Quantum	Information	|0⟩	|1⟩
Electron	Spin	Up	Down
	Charge	None	One electron
Nucleus	Spin	Up	Down
Optical Lattices	Spin	Up	Down
Quantum Dot	Dot Spin	Down	Up
Photon	Polarization of Light	Horizontal	Vertical

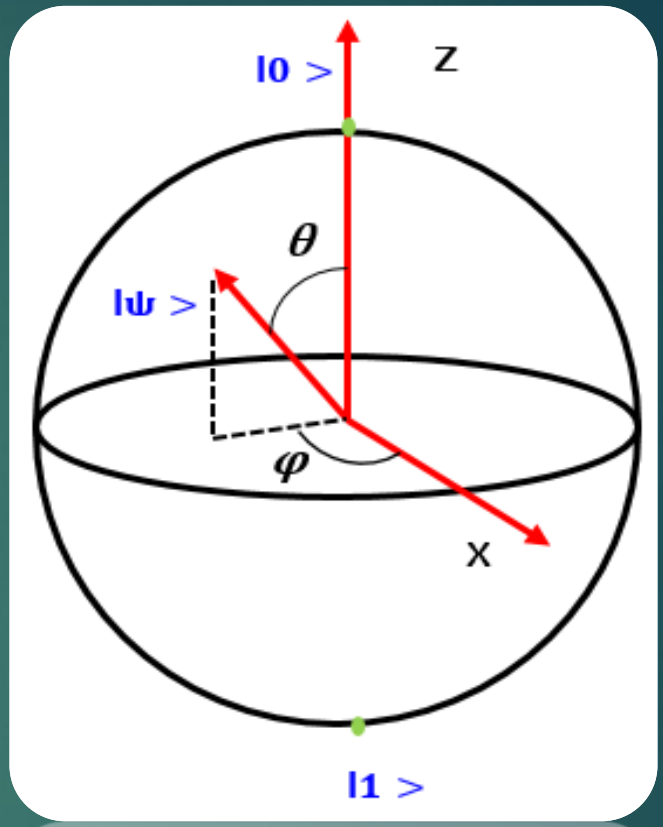
(a)

	Fermion	Boson
Quantum	Proton, Neutron, Electron, Neutrino	Photon, Gluon, Higgs, Gravity
Spin	Half-integer	Integer

(b)

Table 1 List of selected physical implementations in quantum [8] and spins in quantum [11].

(a)



(b)

Fig. 2. (a) Quantum computing in nuclear industry and (b) Bloch sphere for Qubit [9].

2. Methods

- There is the basic principle of the entanglement of quantum computing. For the mathematical form, the linear notion of a single Qubit is [8],

$$| \psi \rangle = \alpha | 0 \rangle + \beta | 1 \rangle$$

- There is the constraint as,

$$|\alpha|^2 + |\beta|^2 = 1$$

2. Methods

- There are the presentations of Bloch sphere in Fig. 2 [10]. There are the descriptions of quantum entanglement.
- Two entanglement qubits in the $| \Phi^{+} \rangle$ Bell state as,

$$\frac{1}{\sqrt{2}} (| 00 \rangle + | 11 \rangle)$$

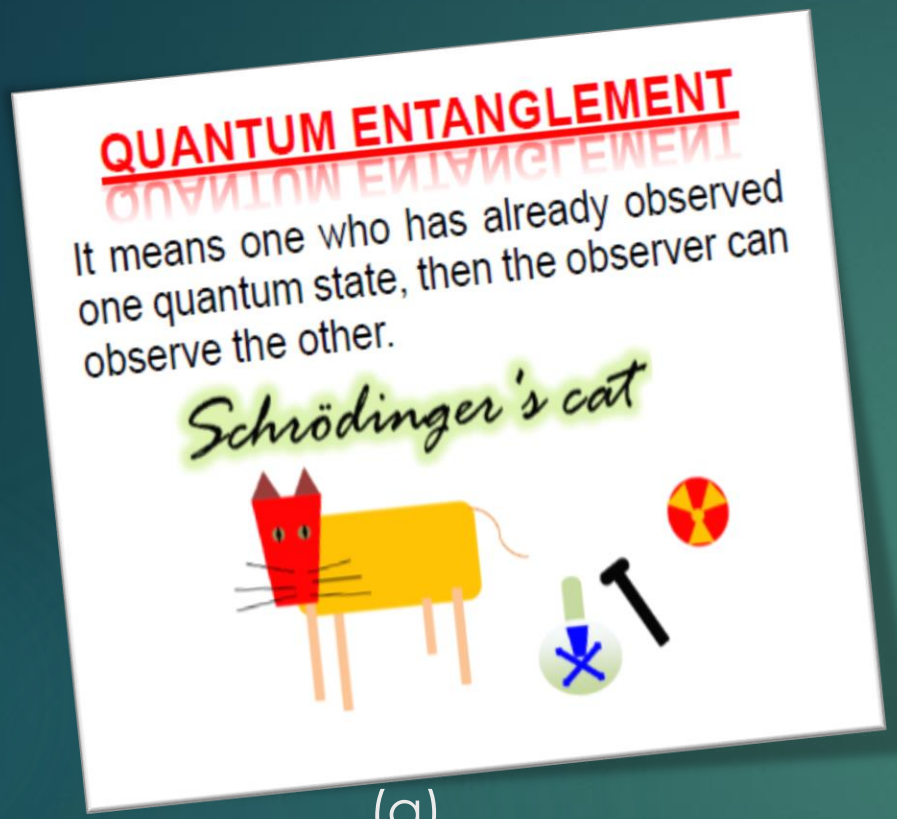
- So, the basis states are as,

$$| 00 \rangle \mapsto | 00 \rangle$$

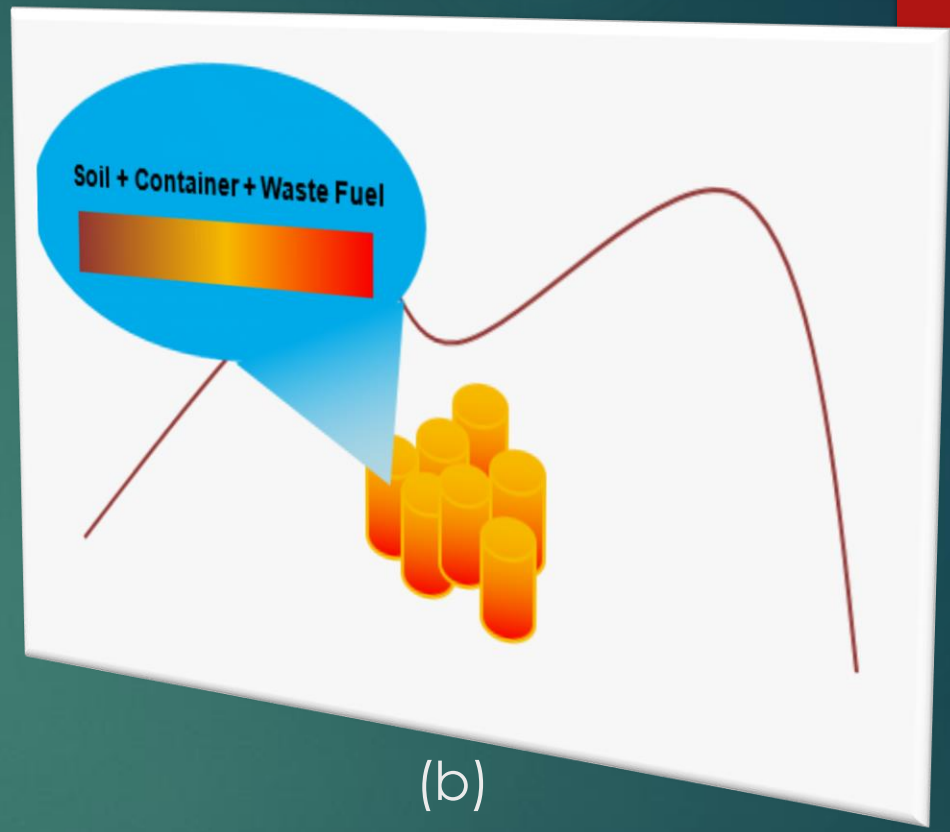
$$| 01 \rangle \mapsto | 01 \rangle$$

$$| 10 \rangle \mapsto | 11 \rangle$$

$$| 11 \rangle \mapsto | 10 \rangle$$



(a)

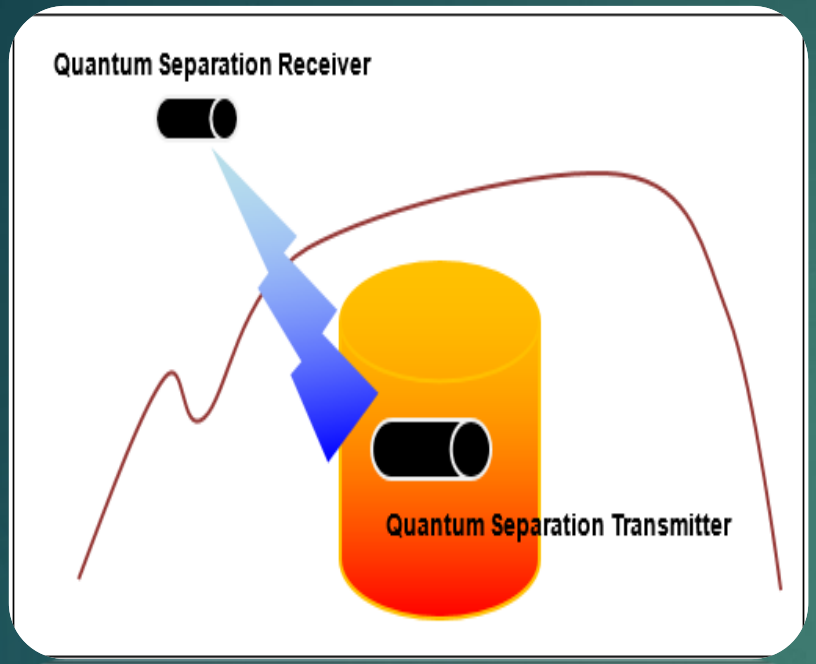


(b)

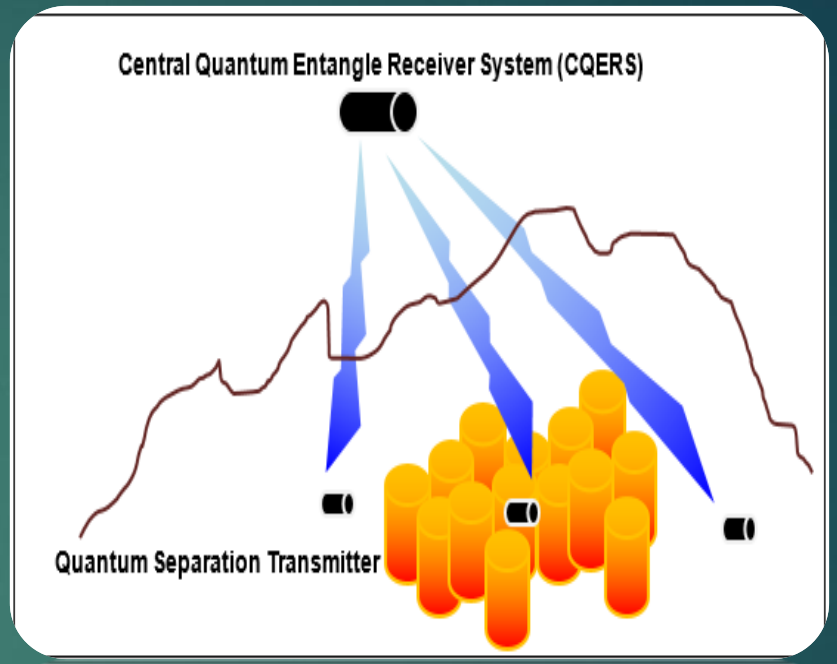
Fig. 3. (a) The meaning of quantum entanglement and (b) Configuration of high-level nuclear waste repository.

3. Results

- Fig. 4 (a) is the transportations of quantum entanglement in the repository site.
- The proposed ‘Quantum Separation Transmitter’ can produce a sampled quantum which is decayed following the time based decay chain from the uranium of the high-level nuclear fuel waste.
- The decayed quantum is emitted to another proposed ‘Quantum Separation Receiver’ in out side of the repository. There is the basic principle of the entanglement of quantum computing.
- In the normal state, most molecules are in a singlet state. Fig. 4 (b) is the proposed mapping of the quantum entanglement system in nuclear waste repository.



(a)

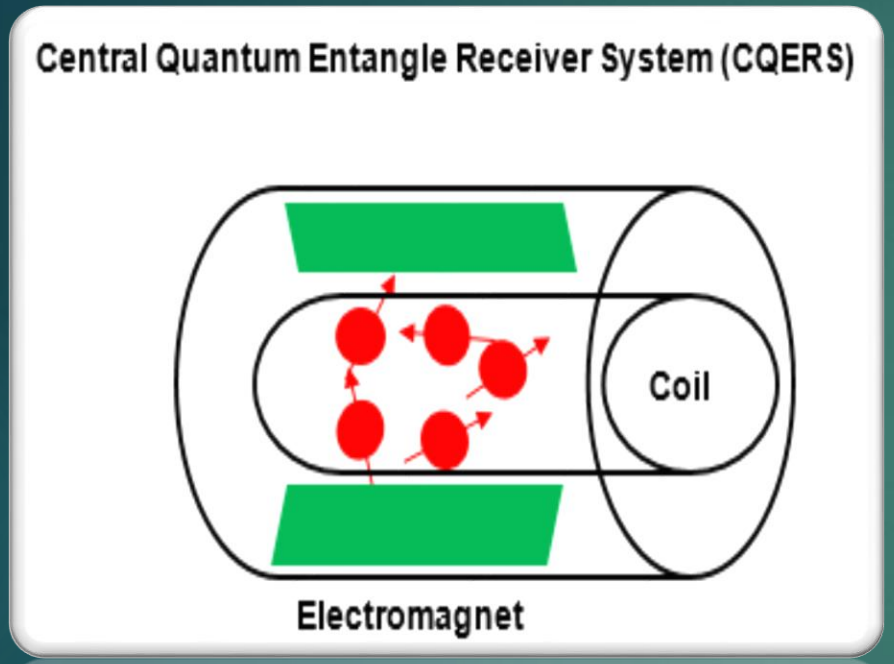


(b)

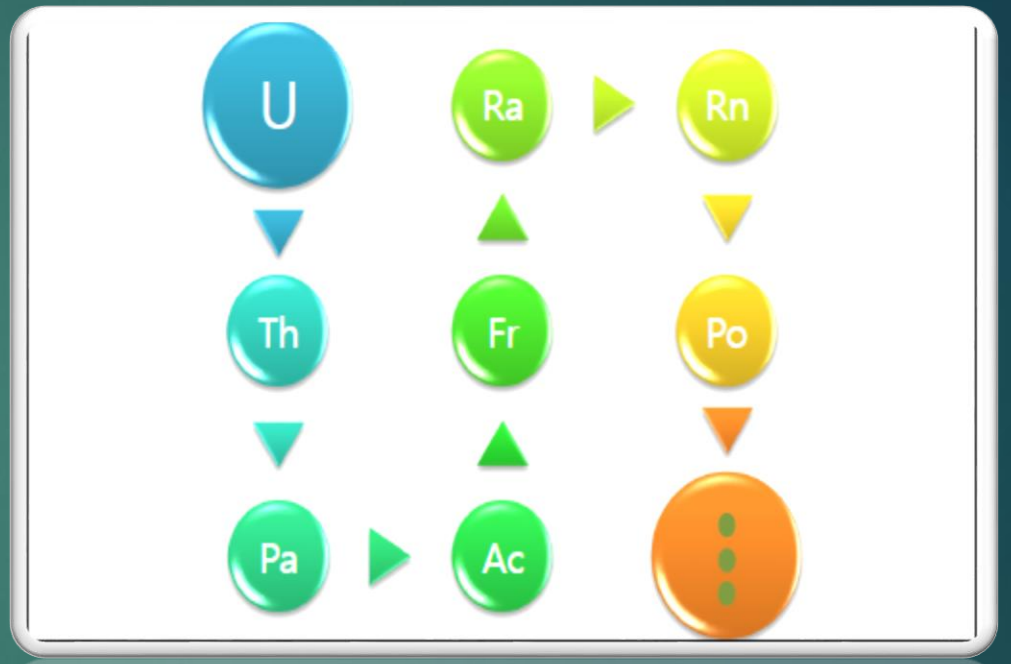
Fig. 4. (a) Transportations of quantum entanglement in the repository site and (b) Proposed mapping of the quantum entanglement system in nuclear waste repository.

3. Results

- Outside of the repository, ‘Central Quantum Entangle Receiver System (CQERS)’ would be constructed, which is in Fig. 5 (a).
- This is the principle of the nuclear magnetic resonance imaging (MRI) system where the electromagnet and coil system can produce the high frequency wave and then the spin could be arranged linearly.
- So, the direction of spin of each proton is formed after disconnecting of the high frequency wave.
- Then, one can find the atomic number of inside atom of repository.
- Fig. 5 (b) has the simplified decay chain of the uranium nuclear waste form where the uranium is the initial atom of 92 protons in the decay chain [13].



(a)



(b)

Fig. 5. (a) Proposed Central Quantum Entangle Receiver System (CQERS) and (b) Simplified decay chain of the uranium nuclear waste form [11].

3. Results

- The simulations are done by the ‘Quantum Separation Transmitter’ where the protons in fermion are transmitted as the singlet spin.
- Then the atomic states of the transmitted are found.
- Fig. 6 shows the proton numbers in the interested region where the 92 is in the initial time during 1000 years.
- Then the singlet state in the CQERS is in the initial state.
- As time goes on, the graph would be changed to lower proton numbered atom.

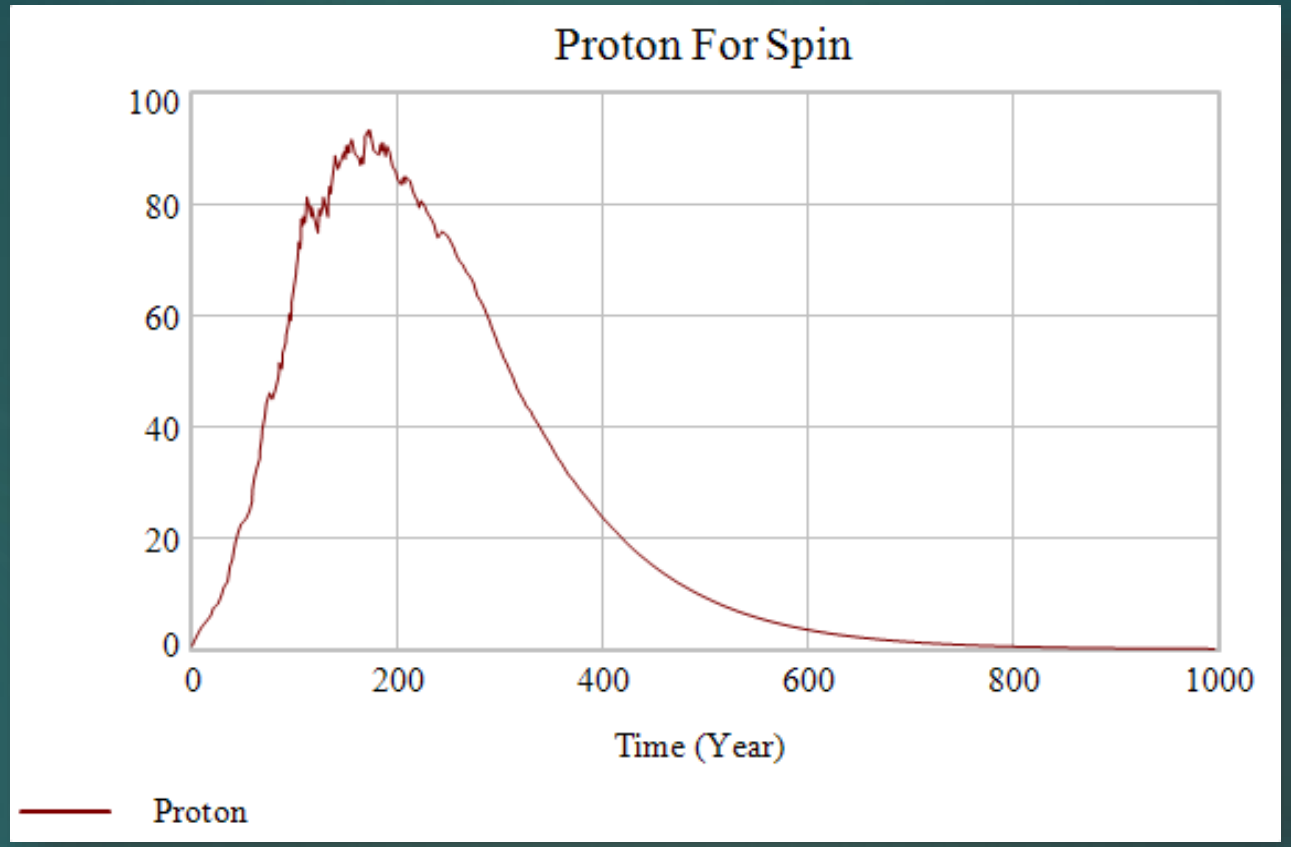


Fig. 6. Proton numbers in a region.

4. Conclusions

- The Bell state forms part of the setup of the superdense coding, quantum teleportation, and entangled quantum cryptography algorithms [8].
- Following the application of the high-level nuclear wastes, the quantum computing usages could be extended in the nuclear industry.
- Furthermore, the reactor analysis in the aspect of the complex calculations of the neutron transportations can be applied using quantum computing as the aspect of the quantum characteristics.

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Thank you !

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