Introducing Hyper-Cold Fusion

Experimental Plan for Cold Fusion Using the Latest 2D Materials

Nano Fusion Design

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About Nano Fusion Design

- Founded by Ryoji Furui in November 2023 to realize nuclear fusion using graphene materials. (1)
- Excess heat has not been confirmed with graphene material and hydrogen under pressures below 10 atmospheres. (2)
- Confirmed excess heat with terahertz pulses. (3)

- Experiments are planned using terahertz-emitting graphene (4) and borophane (mass hydrogen density 8.5 wt%, volumetric hydrogen density 133.4 kg/m3) as hydrogen carriers.

(1) JCF-24 website https://jcfrs.org/news/jcfmtg/807/. Proceeding preprint https://github.com/nanofusion/basic/blob/main/jcf24proceedings_RFurui2D.pdf
(2) Wataru Ishida, Hiroki Miyaoka, Takayuki Ichikawa, Yoshitsugu Kojima, Hydrogenation properties of lithium intercalated graphite, TANSO, 2008, 233, 136-139. https://doi.org/10.7209/tanso.2008.136
(3) Brillouin Energy, a U.S. cold fusion company that has achieved COP2.5 with terahertz pulses, was introduced in a December 2024 paper. https://www.researchgate.net/publication/386873037_Charge_Clusters_Low_Energy_Nuclear_Reactions_and_Electron_Structure
(4) Stephane Boubanga-Tombet, Wojciech Knap, Deepika Yadav at el., Room-Temperature Amplification of Terahertz Radiation by Grating-Gate Graphene Structures, Phys. Rev. X 10, 031004 (2020). https://journals.aps.org/prx/abstract/10.1103/PhysRevX.10.031004

What is Cold Fusion?

- A dream energy source that has continued to be researched and developed since its discovery about 30 years ago. (5)
- Unlike fusion that heats impurity-free hydrogen fuel to 1 billion °C, cold fusion achieves fusion with hydrogen absorbed into metals like nickel at temperatures below 1000°C.
- Fusion reactions have been confirmed, but are still developing as a highly efficient and quantifiable practical energy source.

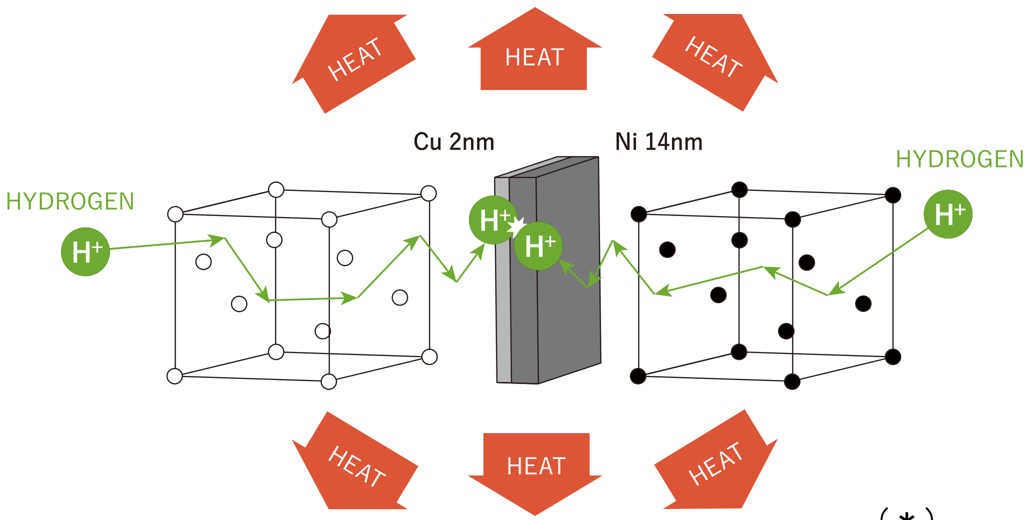
- "Hyper-Cold Fusion" - Solving various problems and realizing dream energy with the latest 2D materials!

(5) M. Fleischmann and S. Pons, Electrochemically induced nuclear fusion of deuterium, *J. Electroanol. Chem. Int. Electrochem.* 261 (1989) 201.

What is Hyper-Cold Fusion?

Cold Fusion

- Using metals with a 3D structure to occlude hydrogen
- Near-vacuum state



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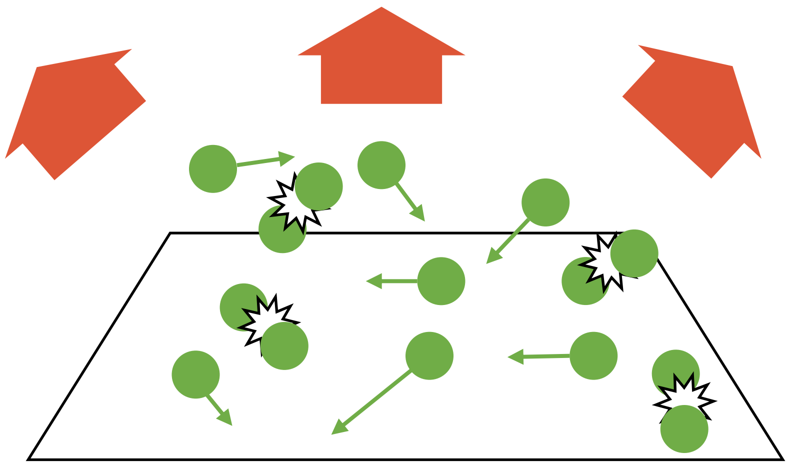
Hyper-Cold Fusion

- Fusion reaction on 2D material surface
- Requires high pressure gas → "Hyper"

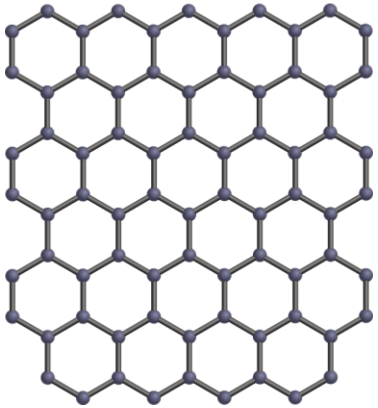


（＊） What is the heat generation phenomenon of QHe? - Scientific Figure on Clean Planet. Available from: https://www.cleanplanet.co.jp/technology/ [accessed 22 Jan 2025]

About Graphene and Borophane

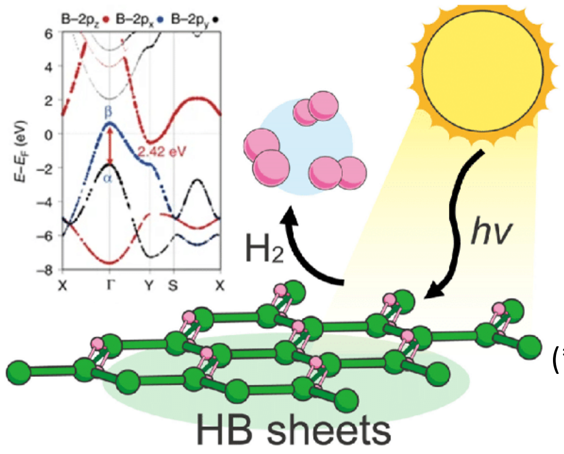
Graphene

- Hexagonal carbon lattice, melting point 3000°C
- Fermi velocity 6000 km/s (copper is 1600 km/s)
  ⇄ Terahertz oscillation
- Medium to convert hydrogen to ultralow-momentum neutrons via electron capture (6)



Borophane (Borohydride Sheet)

- First produced in Japan in 2017 (7)
- Composed of hydrogen and boron in a 1:1 ratio, releases hydrogen when exposed to ultraviolet light or heated above 200°C
- Fusion fuel, hydrogen and boron fuse to form helium



(*)

(6) New Energy Times: Webpage summarizing the electron capture theory https://newenergytimes.com/v2/sr/WL/WLTheory.shtml
(7) Formation and Characterization of Hydrogen Boride Sheets Derived from MgB2 by Cation Exchange. Hiroaki Nishino, Takeshi Fujita, Nguyen Thanh Cuong, et al. Journal of the American Chemical Society 2017 139 (39), 13761-13769, DOI: 10.1021/jacs.7b06153, https://www.jstage.jst.go.jp/article/tanso1949/2008/233/2008_233_136/_article/-char/en
(*) Hydrogen Generation Induced by Ultraviolet Light Irradiation on Hydrogen Boride Sheets - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/color-online-Schematic-image-of-the-hydrogen-release-from-hydrogen-boride-HB-sheets_fig2_342848044 [accessed 10 Jan 2025]

Fusion Process with Electron Capture

1. Hydrogen desorbs from borophane heated above 200°C.

2. Hydrogen collides with fast electrons on graphene and converts to neutrons.

   p (light hydrogen) + e (electron) → n (neutron) + ν_e (neutrino)

3. Neutrons fuse with boron and convert to helium, releasing nuclear energy. (8)

   n + B (boron) → 3He (helium) + e + $\overline{\nu}_e$ (antineutrino) (Q = 8.68 MeV)

Just 1 g of borophane releases excess heat equivalent to the combustion energy of 600 kg of oil!

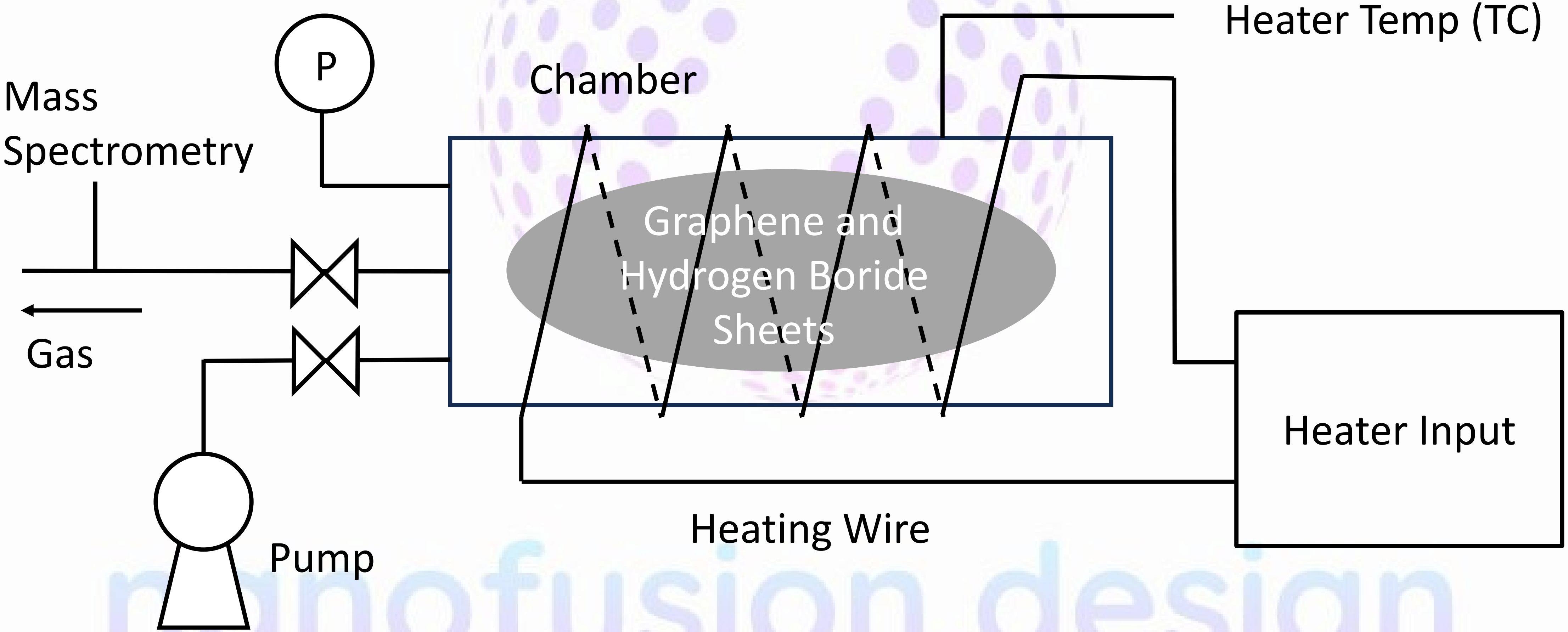
(8) Nespoli, F., Masuzaki, S., Tanaka, K. et al. Observation of a reduced-turbulence regime with boron powder injection in a stellarator. Nat. Phys. 18, 350–356 (2022). https://doi.org/10.1038/s41567-021-01460-4

Magee, R.M., Ogawa, K., Tajima, T. *et al.* First measurements of $p^{11}B$ fusion in a magnetically confined plasma. *Nat Commun* **14**, 955 (2023). https://doi.org/10.1038/s41467-023-36655-1

Experimental Procedures

1. Encapsulate powdered graphene and borophane in a pressure-resistant container of 1–100 mL, with a vacuum level of 1×10^{-3} [torr] to several hundred MPa, and perform vacuum evacuation. (During the initial stages of the experiment, the container performance can be low-spec, gradually increasing in stages)
2. Heat the container's outer wall to several hundred °C for several hours with an electric heating wire wrapped around.
3. Confirm excess heat on the outer wall (heat generation due to fusion).
4. After stopping heating, cool to room temperature.
5. Collect and conduct mass spectrometry analysis on the gas inside the container.

Diagram of the Experimental Setup



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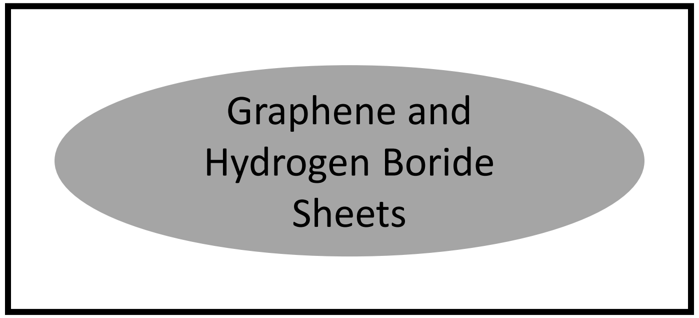
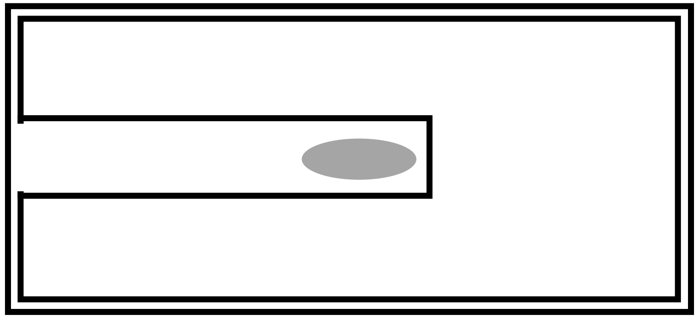
1st Model Specifications

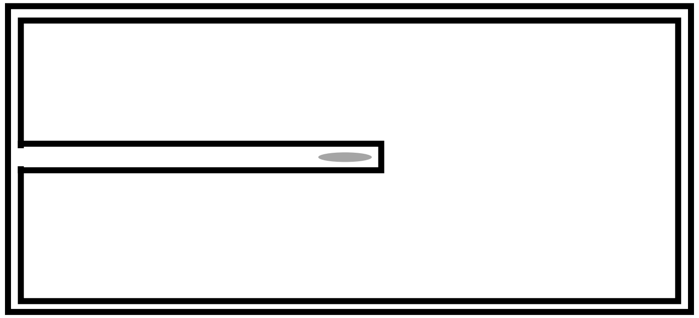
- Container Material: Hastelloy X, etc.
- Container Capacity: 100 mL   Loading Volume: 50 mL
- Design Pressure: 150 MPa   Operating Pressure: 135 MPa
- Design Temperature: 1000°C   Operating Temperature: 750°C



100 mL Bulk



With 10 mL Core Socket



With 1 mL Core Socket

Safety Management in Experiments

- Handling High-Temperature, High-Pressure Gas
  - In the experiment, high-pressure hydrogen gas is generated at temperatures of several hundred °C from solid fuel. If it leaks outside the container, there is a risk of hydrogen explosion.
  - The experiment should be conducted with equipment and safety measures in place to anticipate such risks, in accordance with relevant laws.
  - The possibility of excess heat generation due to nuclear reactions should be also taken into consideration.
- Generation of Radioactive Substances
  - High-pressure gas and residual powder generated during the experiment may contain trace amounts of tritium and the radioactive carbon isotope C14.
  - In the initial stages of the experiment, the residual amount is expected to be below regulatory limits (9), but the experiment should be conducted under a management system that includes mass spectrometry of waste.

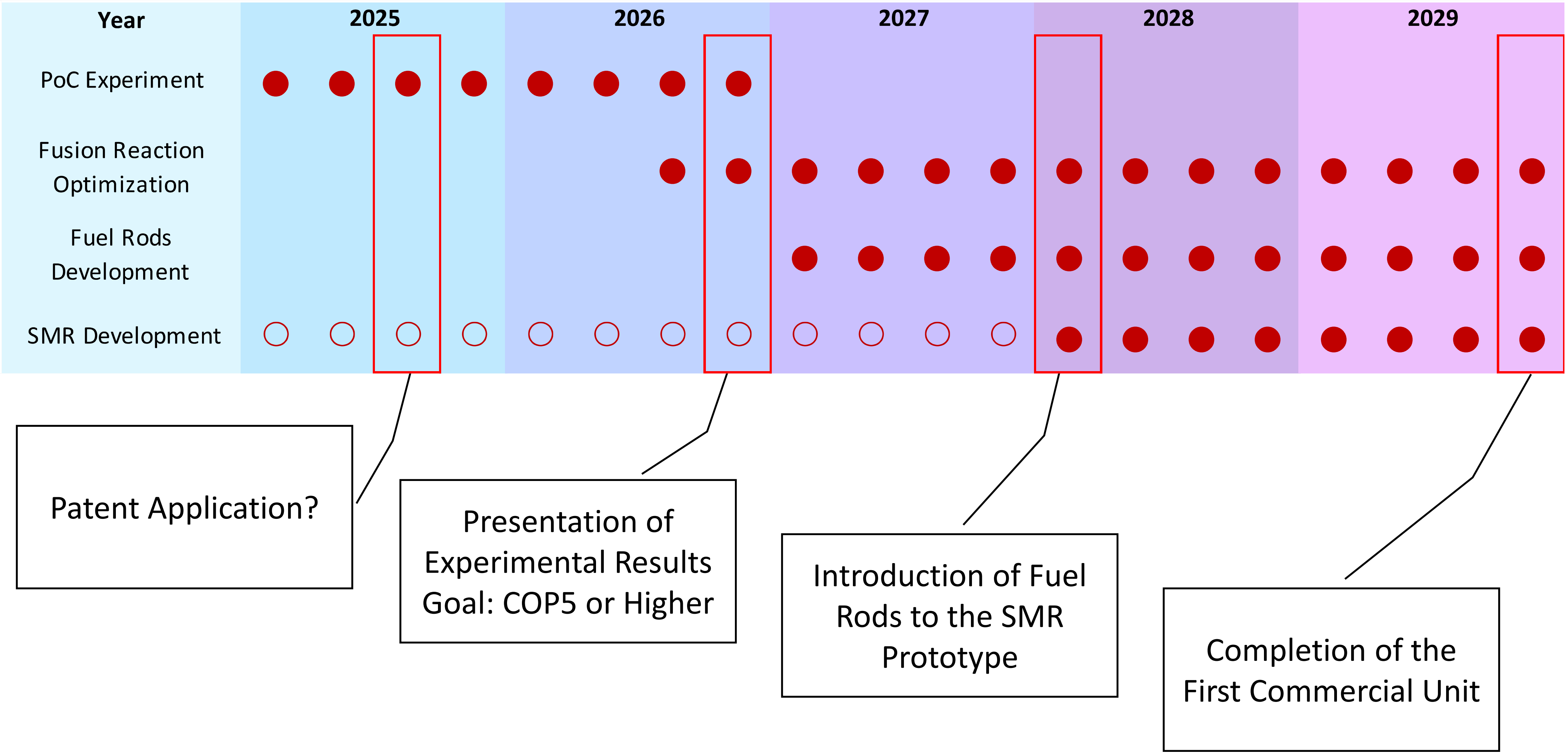
(9) Digital Agency e-Gov Portal: "Act on the Regulation of Radioisotopes, etc." https://www.japaneselawtranslation.go.jp/en/laws/view/3962/en

Development after PoC Experiment

1. Optimization of Fusion Reaction
    - The optimal mixing ratio of graphene and borophane, as well as the powder shape and furnace temperature, will be explored through experiments and computer simulations.
2. Development of Fuel Rods
    - Utilize the new nuclear fuel rod development facility (10) to be established at Tohoku University in March 2025 to develop fuel rods that can withstand high loads and long-term operation.
3. Development of Small Modular Reactors (SMR)
    - Introduce fuel rods that can be operated as heat sources into reactors optimized for their output, and develop complete packages such as boilers or SMRs aimed at power generation.

(10) The Japan News: "Japan Plans Development Base For New Nuclear Fuel Rods; New Cladding Material Aims To Reduce Accident Risk"
https://japannews.yomiuri.co.jp/science-nature/science/20241222-229126/

Project Milestones



Development Funding and Intellectual Property

- Development Funding
  - Nano Fusion Design needs to address the lack of specialized personnel, materials, and funds in the proposed development plan by building a cooperative structure to meet these needs.
- Handling of Intellectual Property Rights
  - The potential intellectual property rights could have widespread public dissemination and utilization as a new energy source.
  - While taking into consideration the development cost of the rights, it is also necessary to exercise the rights in a way that contributes to technological advancement and energy cost reduction.

Hyper-Cold Fusion: Summary

Core Concept

- Hyper-Cold Fusion: Achieve nuclear fusion at low temperatures (below 1000°C) using 2D materials under high pressure.
- Combines graphene (terahertz oscillation, electron capture) and borophane (high hydrogen density) to enable efficient fusion.

Key Innovations

- Materials:
  - Graphene: Converts hydrogen to ultralow-momentum neutrons via electron capture.
  - Borophane: Releases hydrogen at 200°C; fuses with neutrons to form helium ($Q = 8.68$ MeV).
- Process:
  - Hydrogen desorption → neutron conversion → boron fusion → energy release.
  - **1 g borophane ≈ 600 kg oil combustion energy.**

Hyper-Cold Fusion: Summary 2

Experimental Highlights

- Setup: High-pressure (150 MPa), high-temperature (1000°C) reactor with graphene/borophane fuel.
- Safety: Mitigate risks of hydrogen explosions and trace radioactivity (tritium/C14).

Next Steps

- Optimize material ratios and reactor conditions.
- Develop fuel rods and Small Modular Reactors.
- Goal: Achieve COP ≥ 5 and commercialize by 2025–2030.

Thank you!

A New Energy Era Begins

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