# J-PARC facility status and future

**Toshiya Otomo**

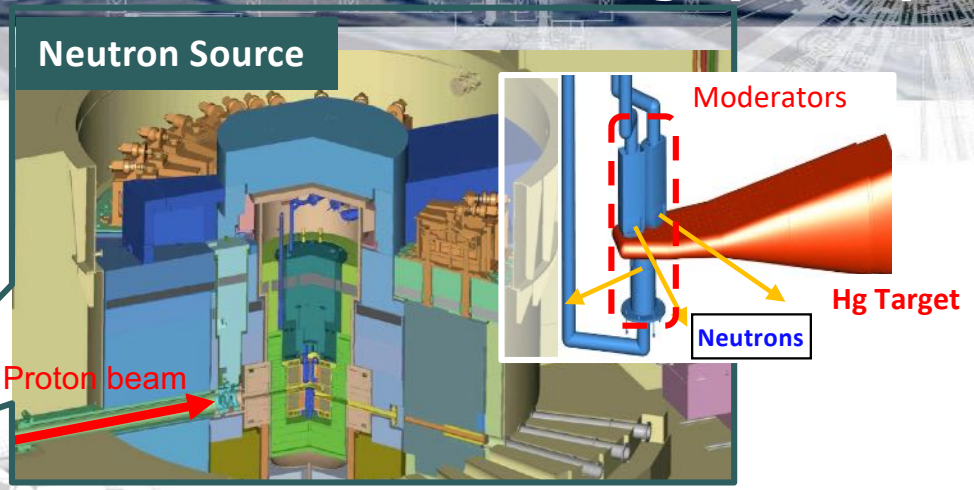
**MLF Division Head**

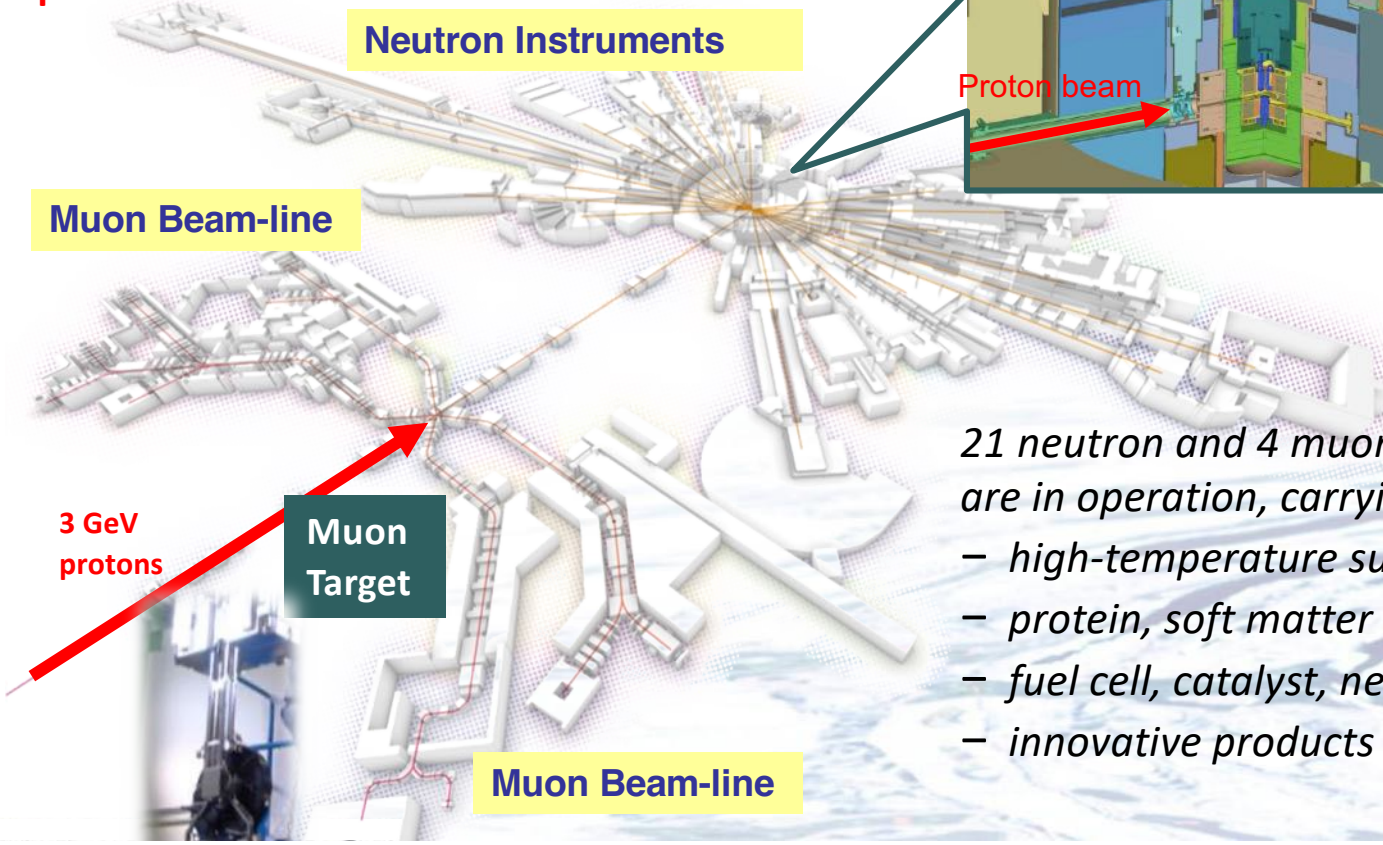
**(Talk given by Kenji Nakajima)**

# MATERIAL AND LIFE SCIENCE EXPERIMENTAL FACILITY

# Materials and Life Science Experimental Facility (MLF)

- **Neutron** and **muon** beams
  - materials science, life science, industrial applications
- **most powerful** neutron and muon sources



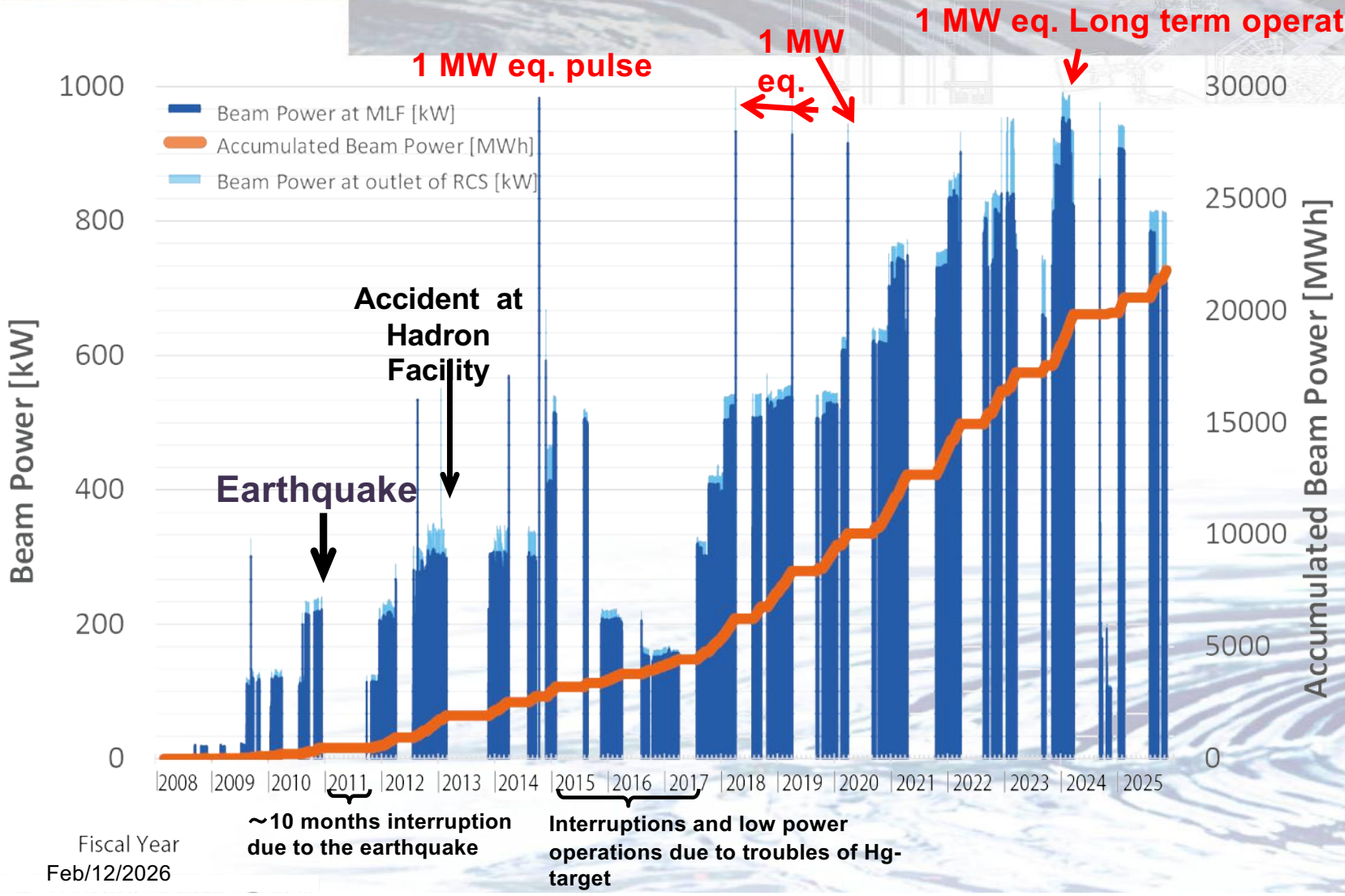

*21 neutron and 4 muon beam lines (8 areas) are in operation, carrying out studies of*

- *high-temperature superconductors*
- *protein, soft matter*
- *fuel cell, catalyst, new materials*
- *innovative products and drugs*

*etc.*

More about MLF

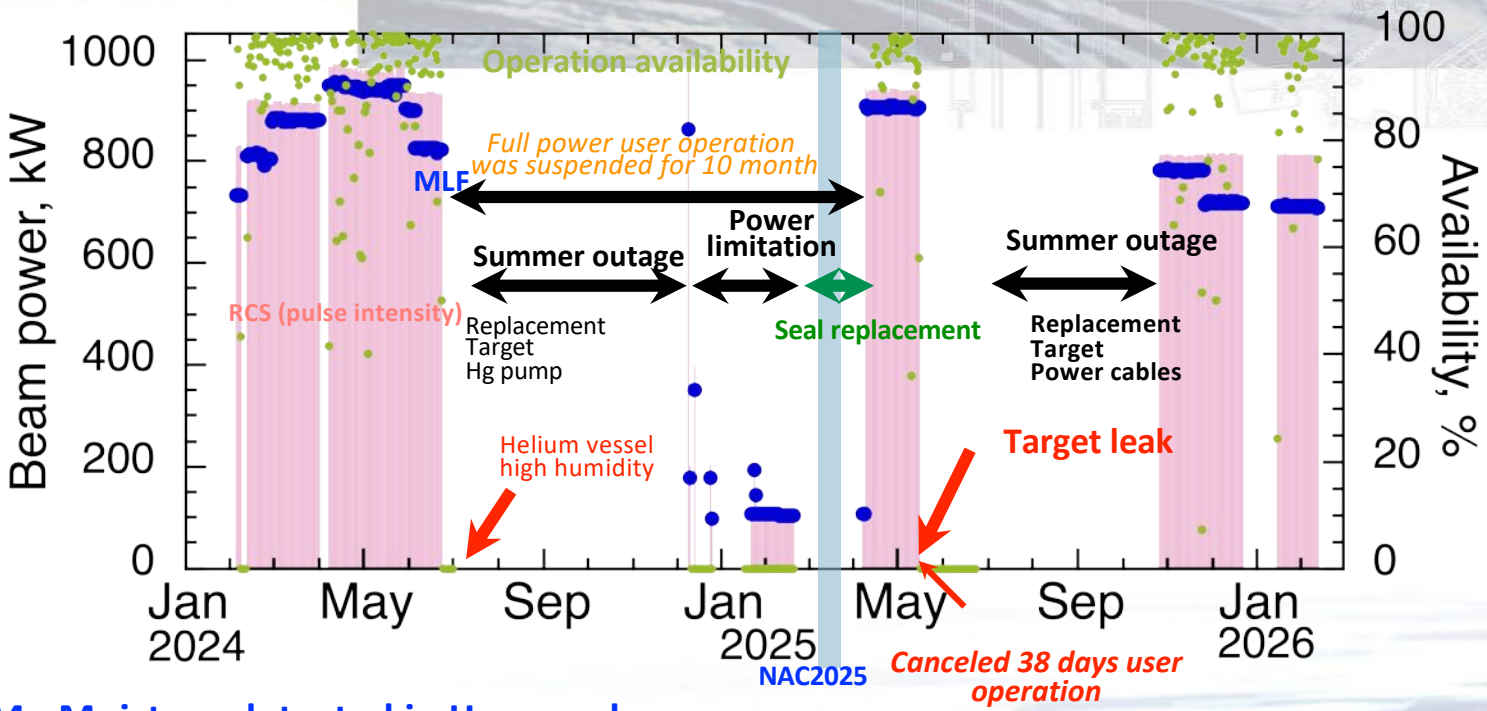
# Beam Power History at MLF




Feb/12/2026

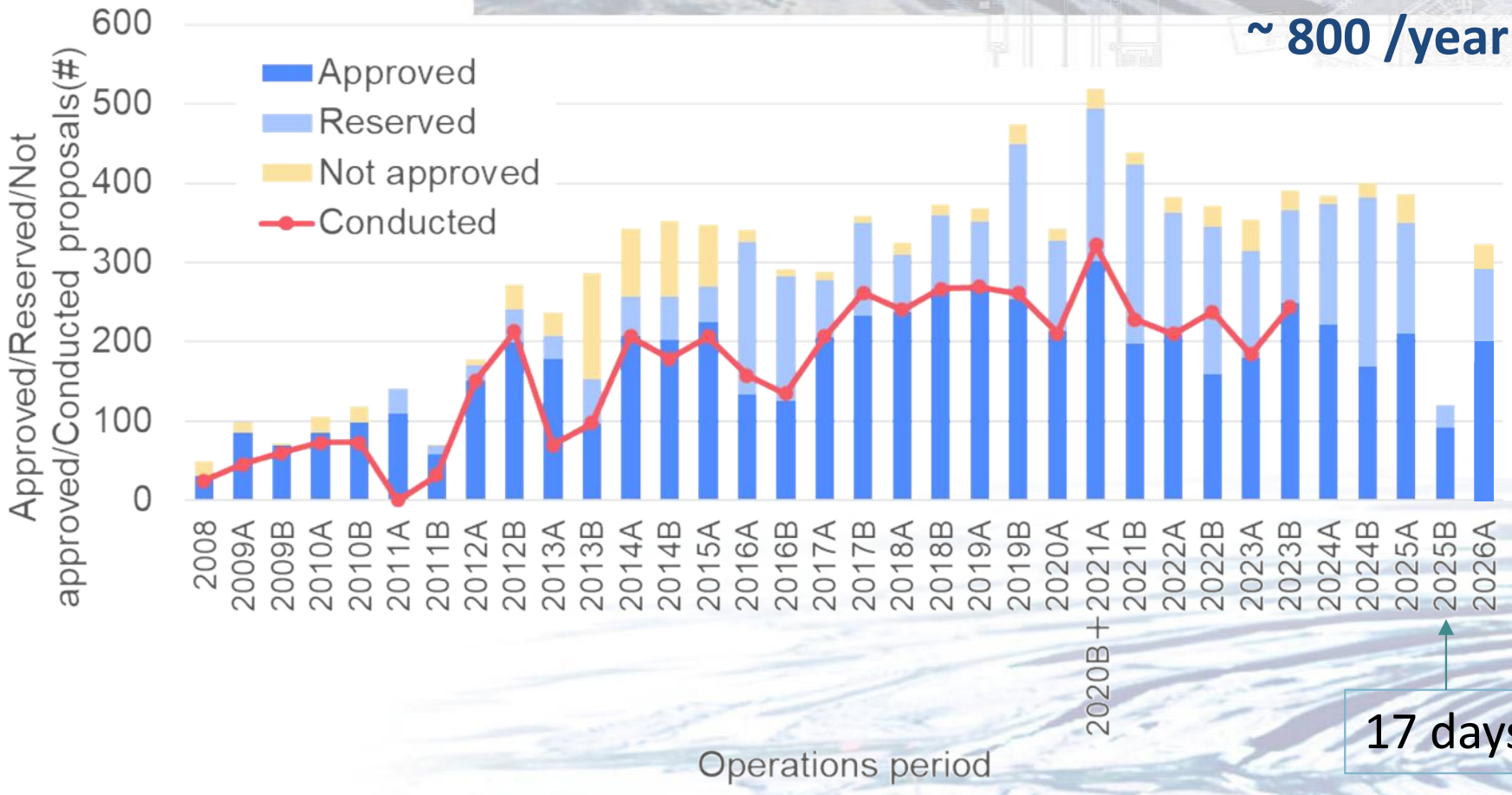
# Target System Challenges






- June, '24 : Moisture detected in He-vessel
- Sept., '24 : Failure of power manipulator cased delay of restart
- Dec., '24 : High-level radiation due to the leak from replaced Hg-pump
- May, '25 : Water leak from cooling water channel of target #16
- June, '25 : Transport used target vessels #11 & #10
- July, '25 : Target vessel replaced to #12 without damage inspection of #16
- Nov. , '25 : Start target #12 operation at 810 kWeq and #12 planning 2-year operation

# Proposals (Neutron & Muon)



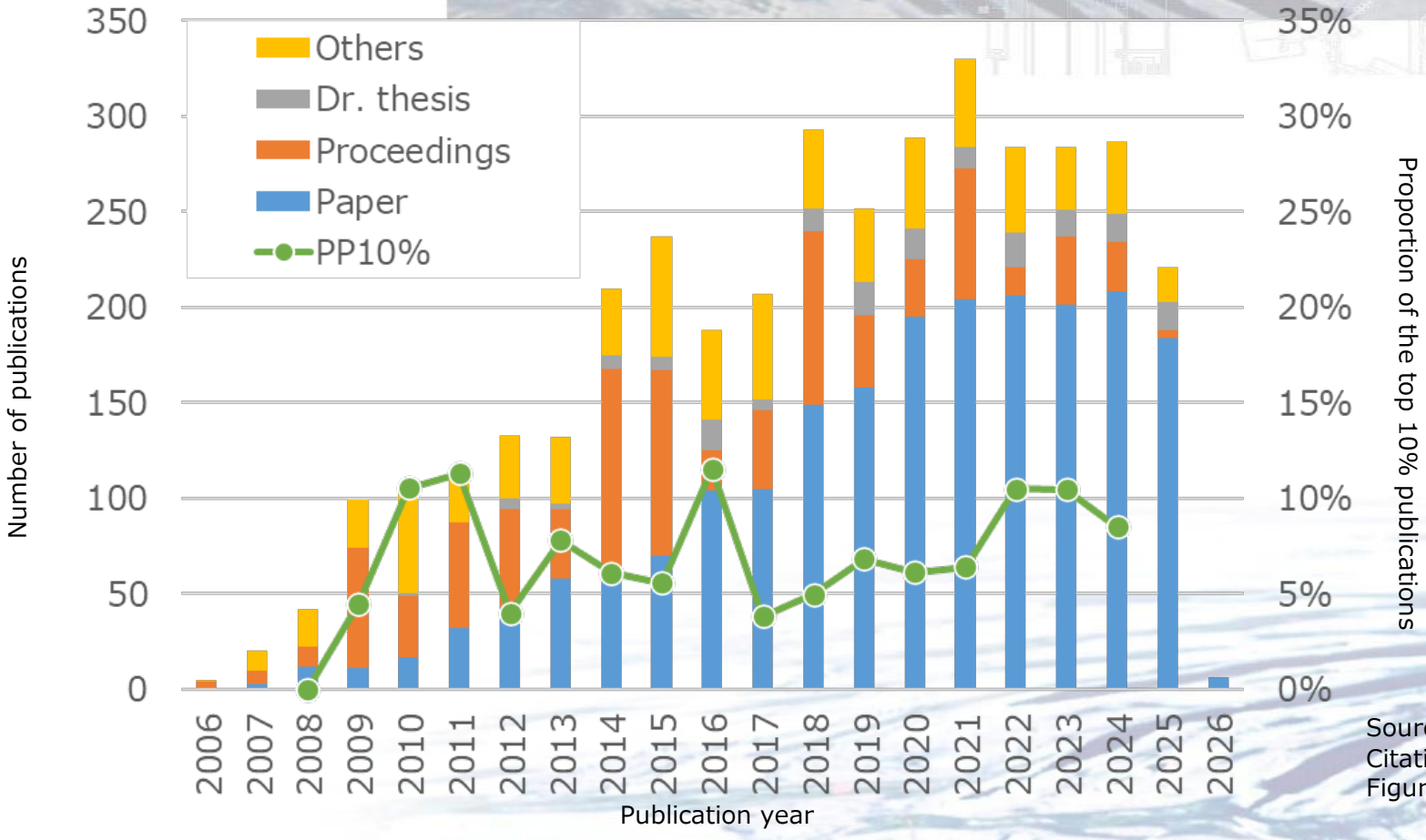

~ 800 /year

More about statistics

17 days

~ 350 / round x 2 round / year
Ave. competition rate ~ 2

# Publications of MLF (neutron & muon)



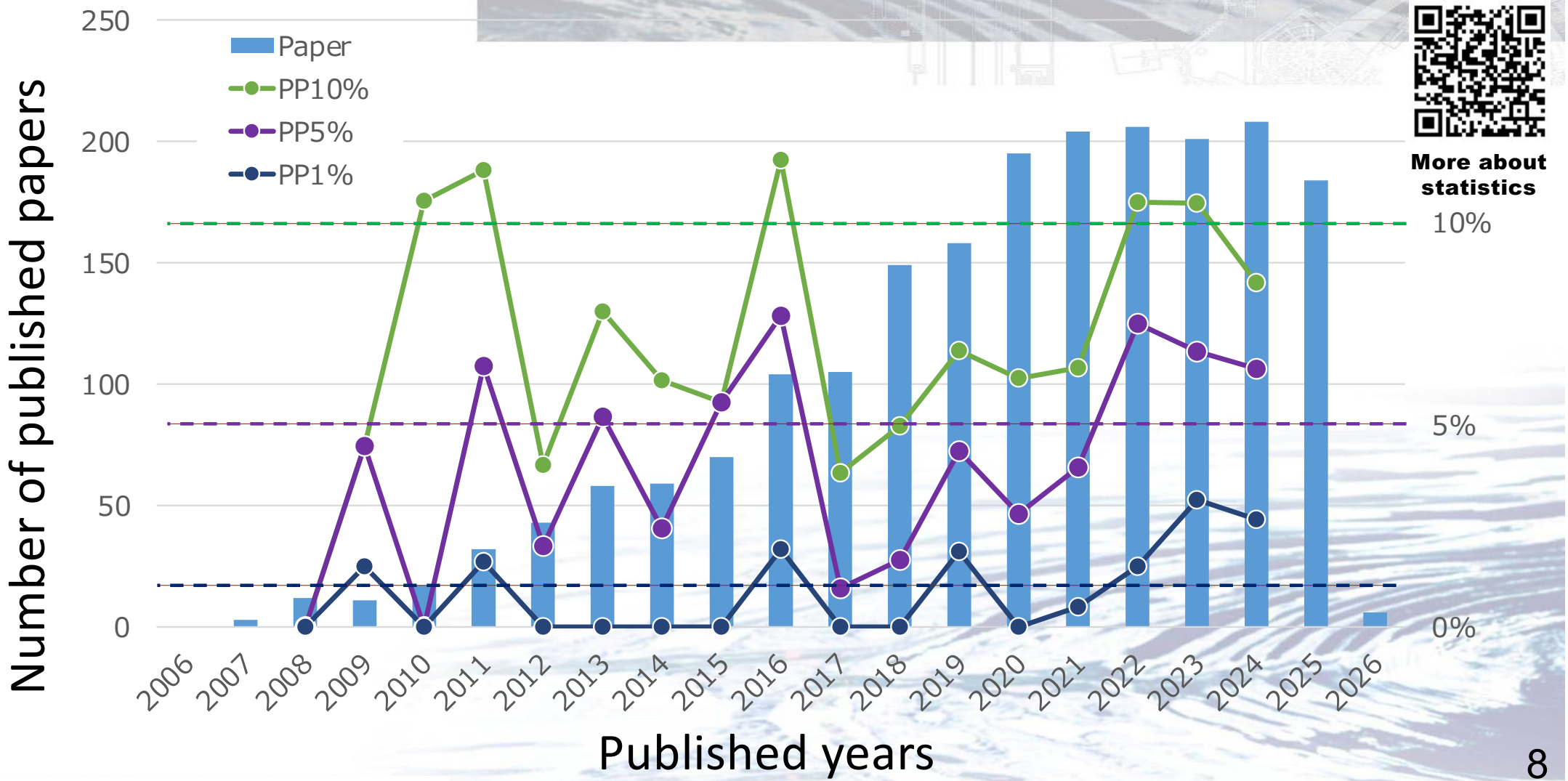

More about statistics

Source data @ 2026-01-08
Citation data @ 2026-01-13
Figure revision @ 2026-01-14

Others : Non-reviewed Papers, Japanese literatures, Master Thesis, etc.

# TOP1% TOP5% TOP10%






More about statistics

# Science Highlights

J-PARC, M

**BL18**

## Discovery of *p*-wave magnet

**Press release: Oct. 23, 2025**

**A metallic *p*-wave magnet with commensurate spin helix**

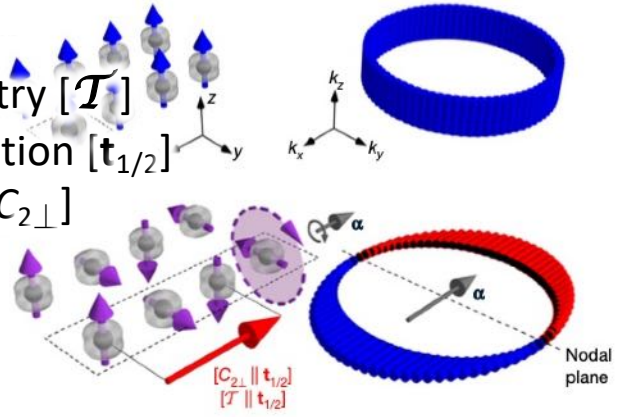
Nature, **646**, 837 (2025)

https://doi.org/10.1038/s41586-025-09633-4
Received: 12 January 2025
Accepted: 15 September 2025
Published online: 22 October 2025

Rinsuke Yamada[1,13✉], Max T. Birch[2,13], Priya R. Baral[1,13], Shun Okumura[1,2], Ryota Nakano[1], Shang Gao[2,12], Motohiko Ezawa[3], Takuya Nomoto[3], Jan Masell[2,4], Yuki Ishihara[1], Kamil K. Kolincio[2,5], Ilya Belopolski[2], Hajime Sagayama[6], Hironori Nakao[6], Kazuki Ohishi[7], Takashi Ohhara[8], Ryoji Kiyanagi[8], Taro Nakajima[2,6,9], Yoshinori Tokura[1,2,10], Taka-hisa Arima[2,11], Yukitoshi Motome[3], Moritz M. Hirschmann[2✉] & Max Hirschberger[1,2✉]

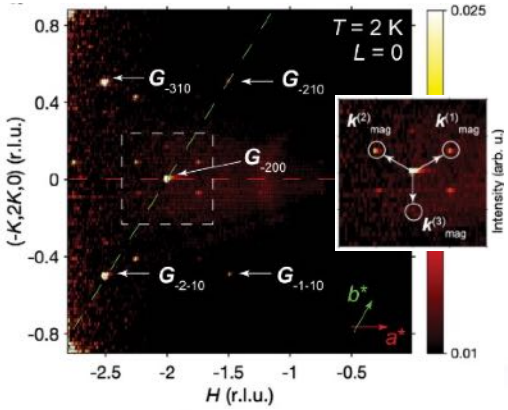
***p*-wave magnet**: An anisotropic spin-split Fermi surface.
↑ and ↓ states exhibit odd parity.

**Requirement**:
- Time reversal symmetry [$\mathcal{T}$]
- a half-unit cell translation [$\mathbf{t}_{1/2}$]
- A 180˚ spin rotation [$C_{2\perp}$]

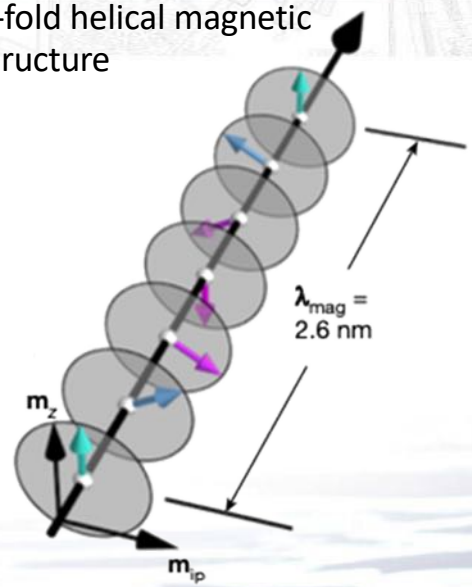


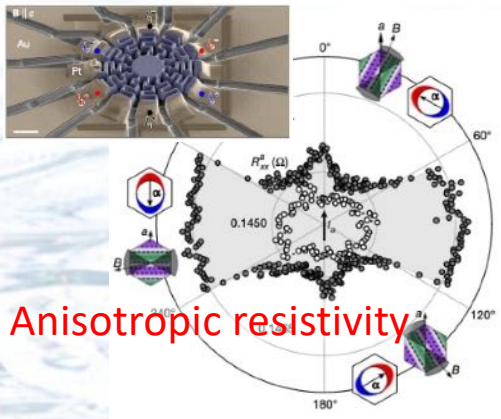

**Candidate**:
- $Gd_3(Ru_{1-\delta}Rh_\delta)_4Al_{12}$

**Observed 6-fold symmetric magnetic satellite reflections**

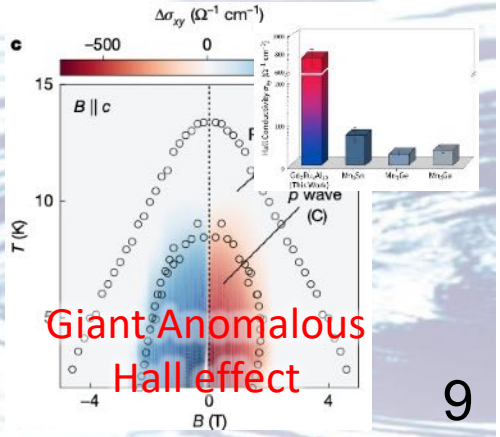



6-fold helical magnetic structure




Anisotropic resistivity




Giant Anomalous Hall effect

# Science Highlights

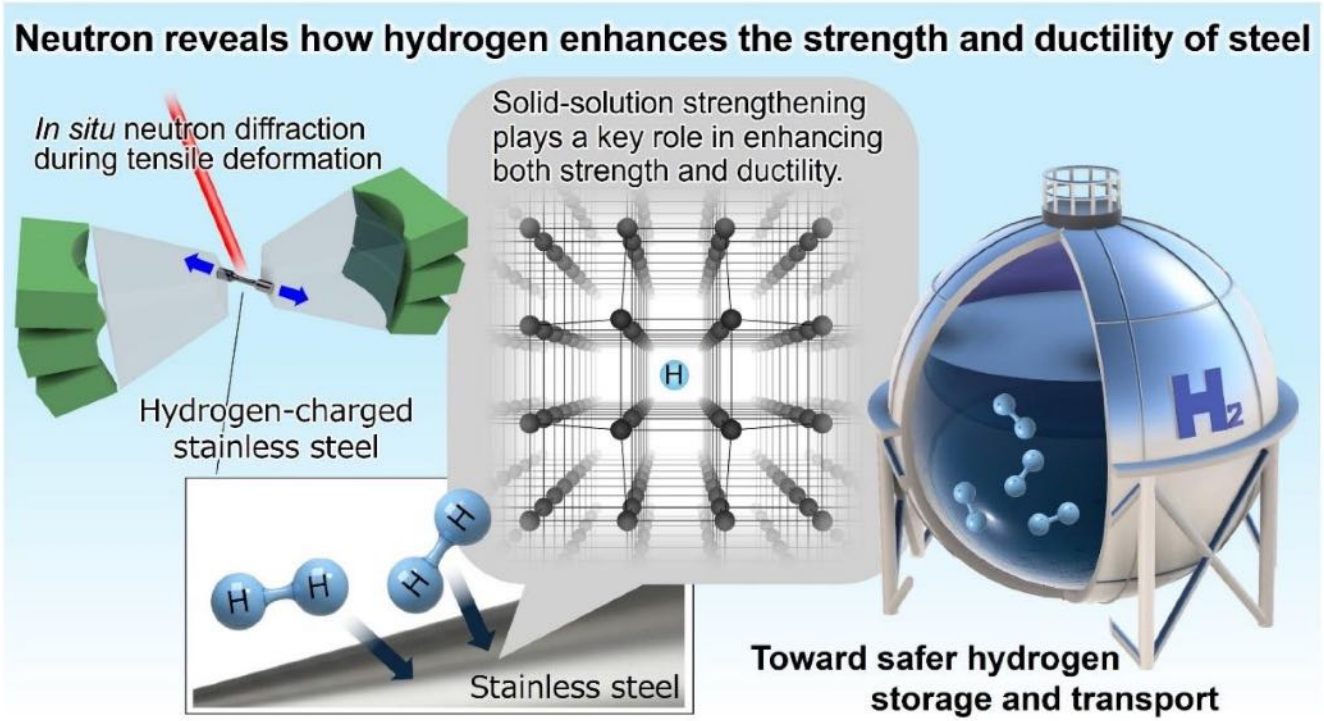
BL19

## Utilizing Hydrogen as a Beneficial Element in Steel Development
## — Investigation of How Hydrogen Enhances the Strength and Ductility of Stainless Steel Using Neutron Diffraction —

**Press release: April 1, 2025**

T. Ito *et al.*, Acta Materialia, **287** (2025) 120767

10.1016/j.actamat.2025.120767




Hydrogen is a promising energy carrier but is known to cause embrittlement in steels. Recent studies show that **hydrogen introduction into Type 310S stainless steel (Fe–24Cr–19Ni) enhances both strength and ductility**.

***In situ* neutron diffraction during tensile testing** revealed that **hydrogen dissolves into the lattice, causing lattice expansion and solid-solution strengthening**.

**The resulting higher stresses promote early deformation twinning, improving ductility** and offering new insights for developing steels for safe hydrogen storage and transport.

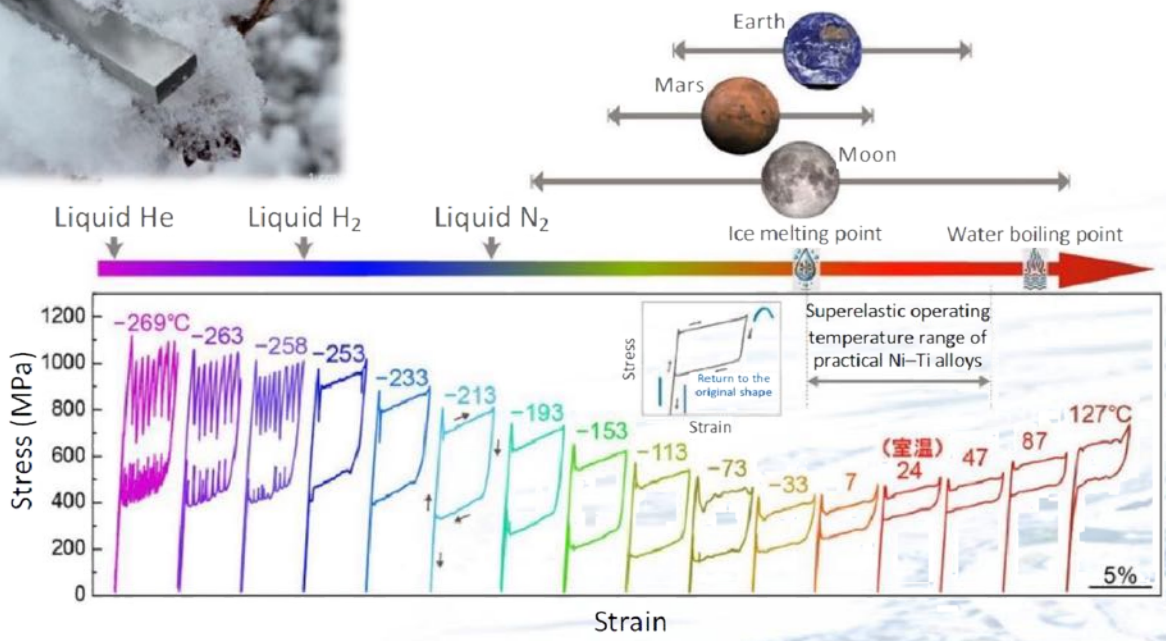
# Science Highlights

**BL18, BL19**

**Press release: Feb. 27, 2025**

## Development of a Lightweight Shape Memory Alloy Exhibiting Superelasticity Across a ~400 ℃ Temperature Range— Promising Applications in Space Environments and Biomedical Fields —

Y. Song, S. Xu *et al.*, Nature, **638** (2025) 965–971 10.1038/s41586-024-08583-7




**Lightweight shape memory alloys** capable of withstanding extreme temperature changes are essential **for space exploration and a hydrogen based society**.

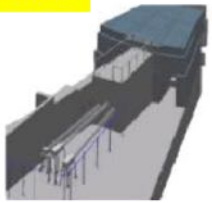
A Tohoku University–led team, with JAEA, the J-PARC Center, and the Czech Academy of Science developed **a Ti–Al–based alloy exhibiting superelasticity from −269 °C to +127 °C**.

**Neutron diffraction experiments** at J-PARC **revealed crystal structure changes and localized deformation propagation underlying the ~400 superelastic range**, enabling applications in space, cryogenic hydrogen systems, and biomedicine.

# Science Highlights



BL05



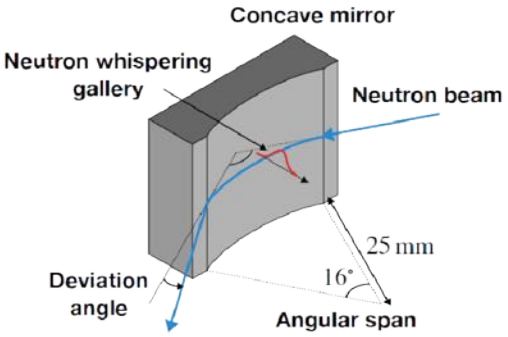
Press release
Apr. 28, 2025

## Measurement of neutron whispering gallery states using a pulsed neutron beam

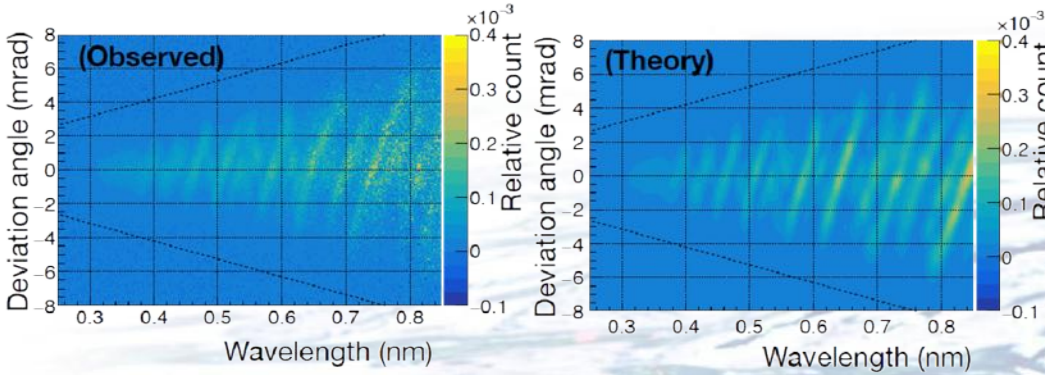
G. Ichikawa and K. Mishima, Phys. Rev. D 111 (2025) 82008.

Received the Young Scier
Award of the Physical Soc
of Japan (2026)

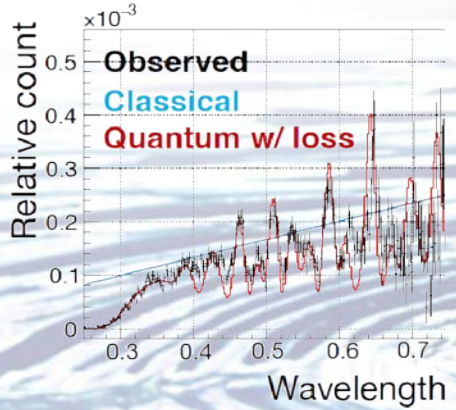
Neutron whispering gallery states are quantum states localized near a concave mirror surface by the centrifugal force and the material potential. We measured such a state with 1.9% agreement with theory, achieving an intrinsic sensitivity of $1 \times 10^{-4}$. These results open prospects for high-precision searches for short-range interactions and tests of the equivalence principle with neutrons.




Neutron whispering gallery and the concave mirror



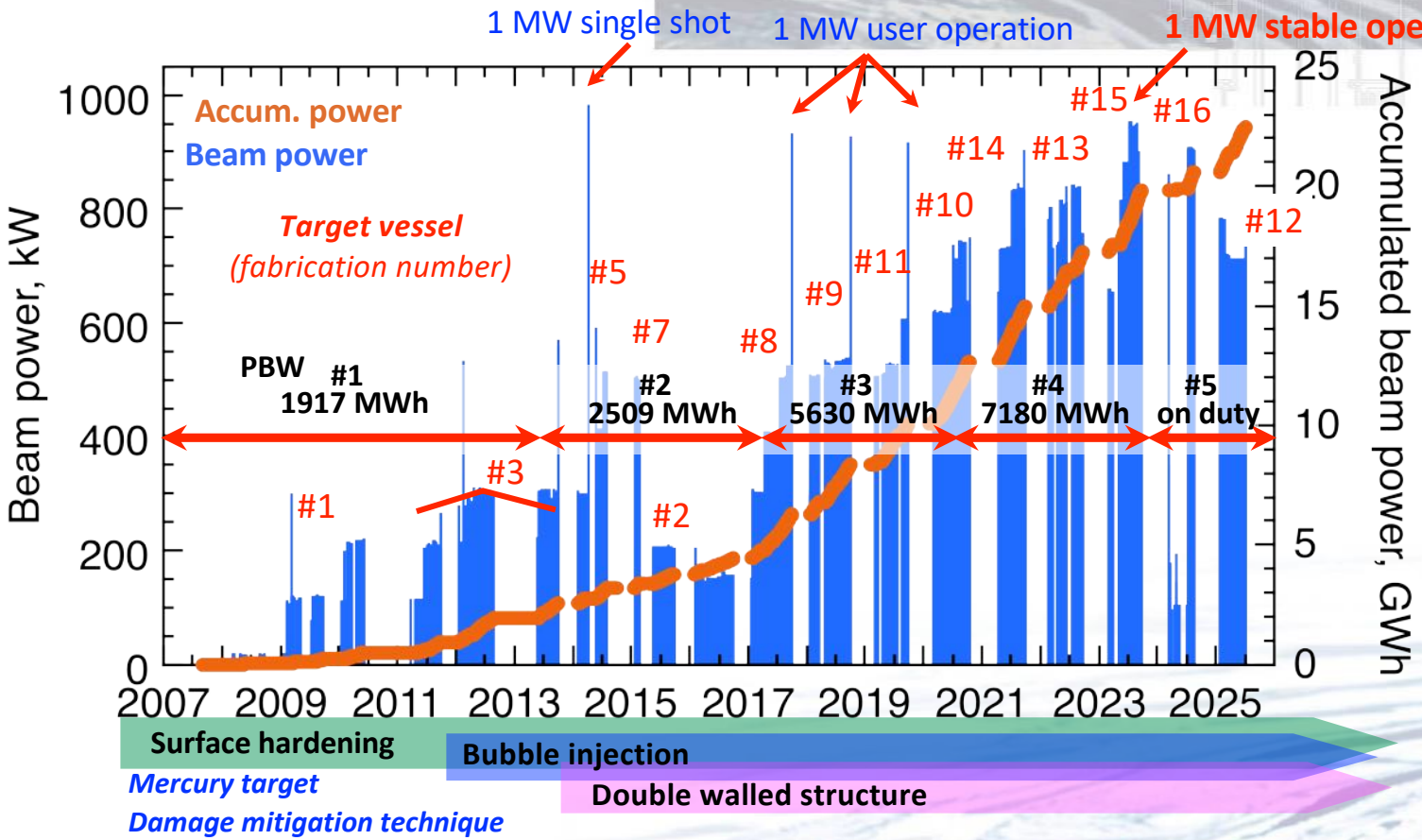

Observed (left) and theoretical (right) distributions

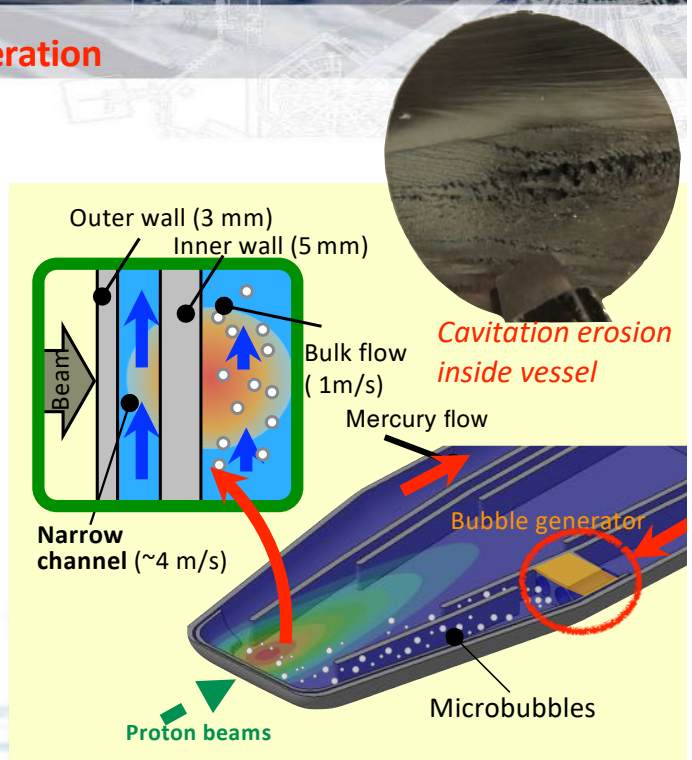



Deviation angle from -0.1 to 0.

# TECHNICAL DEVELOPMENT

# Two Years Operation for One Target Vessel




Damage mitigation techniques

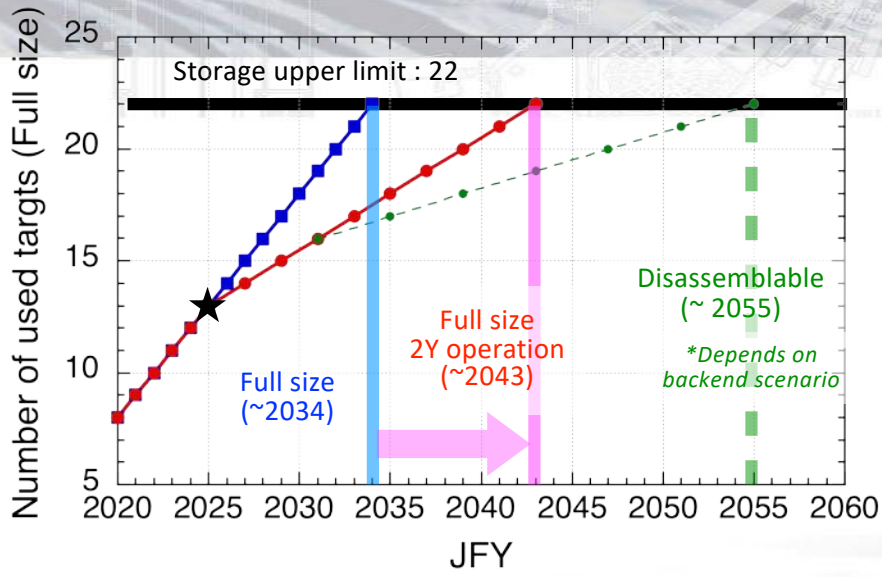
- Successfully achieved stable 1 MW operation (MLF goal) for two months in April 2024 using Target #15
- **Based on measured results of erosion damage inside target vessel and recommendation of an international review, we have decided to use one target vessel for two years**

# Two Years Operation for One Target Vessel

Transport cask (29 ton)
Shielding cask (44 ton)
Storage cask+Target (5.4 ton)


*Transport to RAM building*

*Storage pit in RAM building*






*Disassemble into high and low radioactivity*

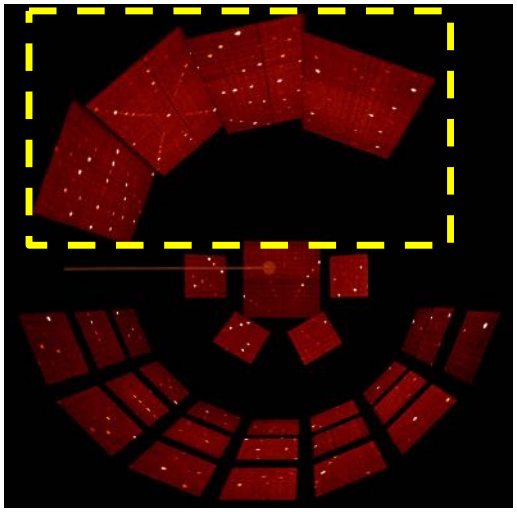
*Mockup test*

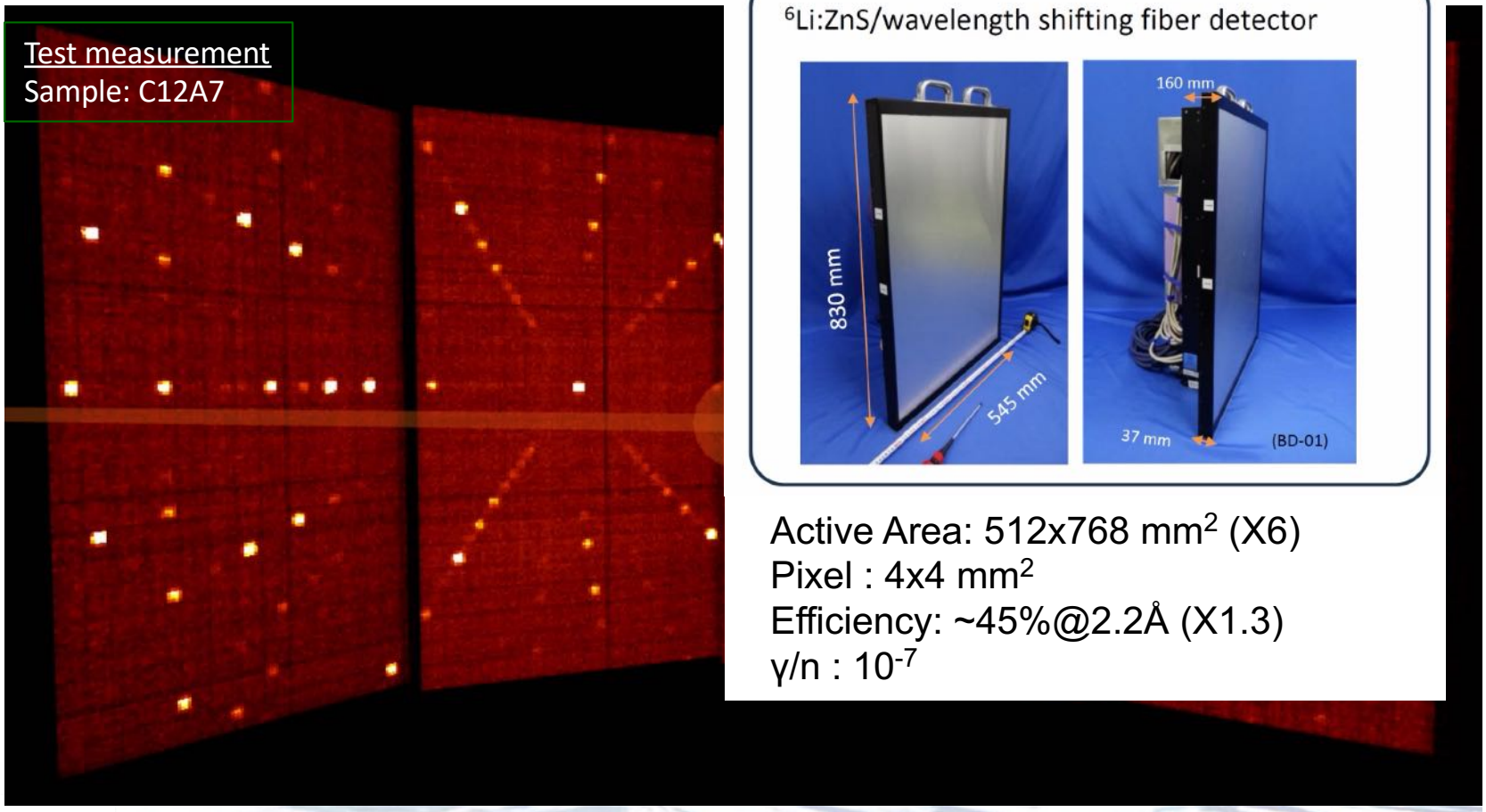
- Disposal scenario of used target is not decided in J-PARC, and storage capacity will be full in 2034
- To continuity operate facility, two years operation for one target is planned with considering the radiation damage and cavitation erosion inside the vessel
- Disassemblable target is under consideration in parallel with build new storage building

# Newly Developed Large Detectors

**SENJU**

New 6Li:ZnS/Wavelength Shifting Fiber Detectors for SENJU






$^{6}$Li:ZnS/wavelength shifting fiber detector

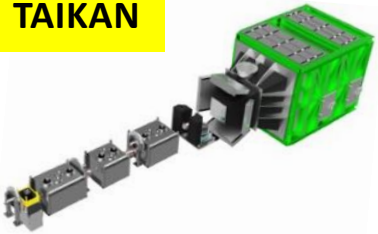


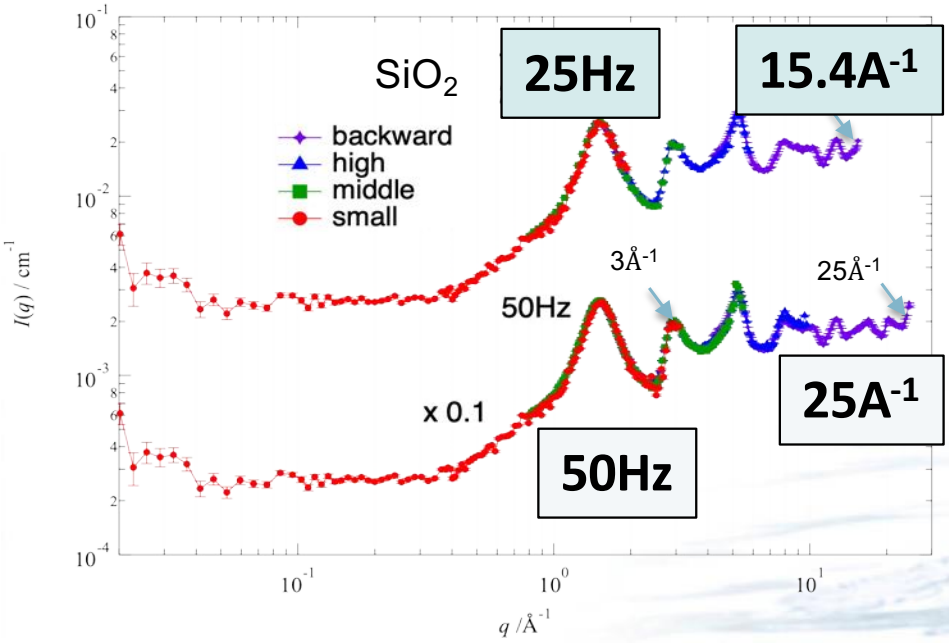

Active Area: 512x768 $mm^2$ (X6)
Pixel : 4x4 $mm^2$
Efficiency: ~45%@2.2Å (X1.3)
γ/n : $10^{-7}$

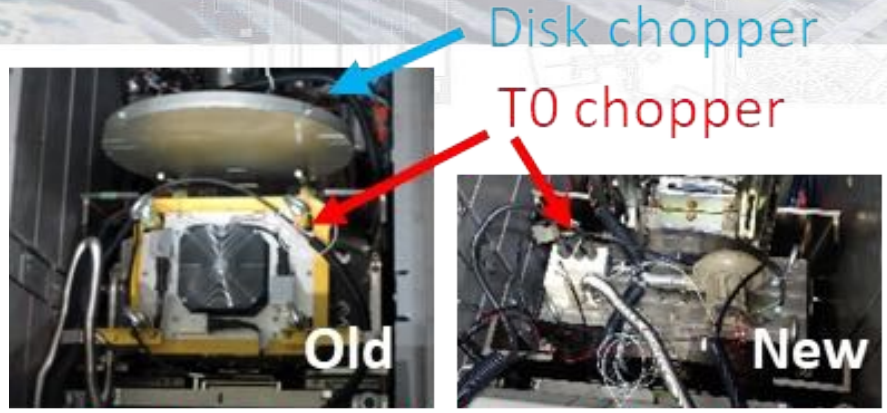
# High-speed T0 chopper for SANS



TAIKAN






Replacement of the T0 chopper

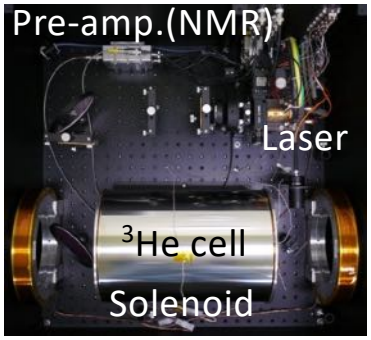
A 50 Hz operation test was performed, and it was confirmed that measurements up to a high-q value of 25 $Å^{-1}$ can be achieved by using short wavelengths down to 0.5 Å.

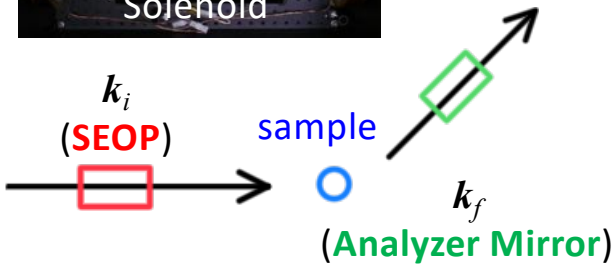
Stable 50 Hz operation of the T0 chopper was previously difficult due to resonance with the disk chopper.
Therefore, a new T0 chopper, which enables operation up to 100 Hz, was installed in this fiscal year and is now available for user experiments.

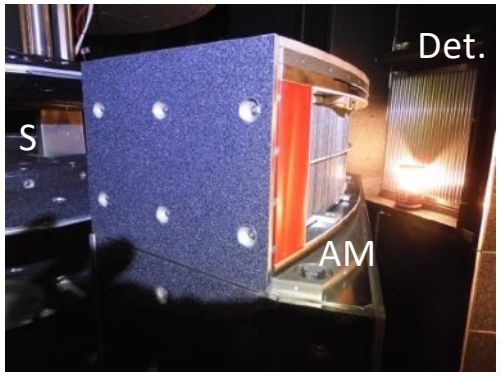
# Polarized Neutron Chopper Spectrometer

**POLANO**

## Polarization analysis

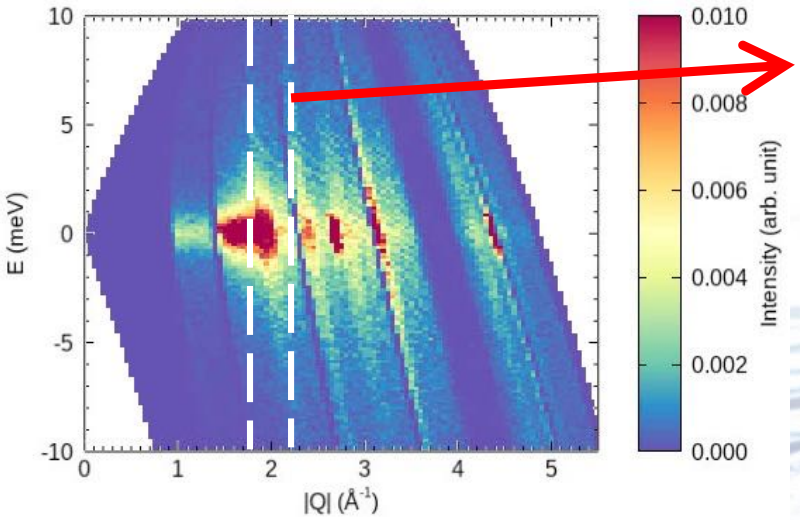



**SEOP** : Spin Flip by NMR

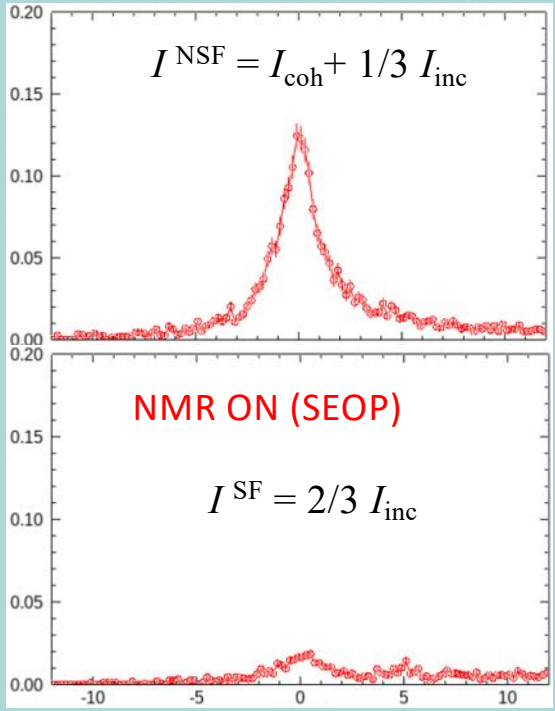
**Analyzer** : Scanning by the super mirror package (Assemble of the 5.5 Qc bending supermirrors)




**Polarization analysis** : By scanning the analyzer, we can map out an inelastic signal in a wide ***Q***-ω space.

Deuterated Methyl acetate
( $C_3D_6O_2$ )

***Q*** = 1.8 – 2.2, $2th_{AM}$ = 35 deg.



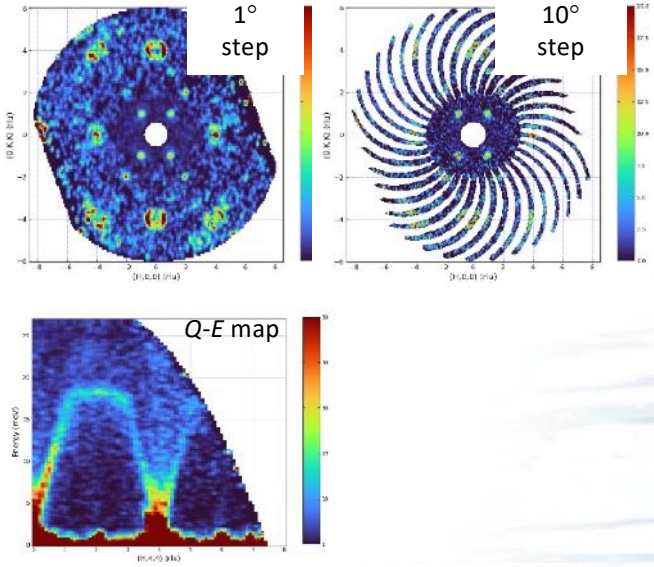
# Continuous Rotation Scan Mode Development

**SIKI & AMATERAS**

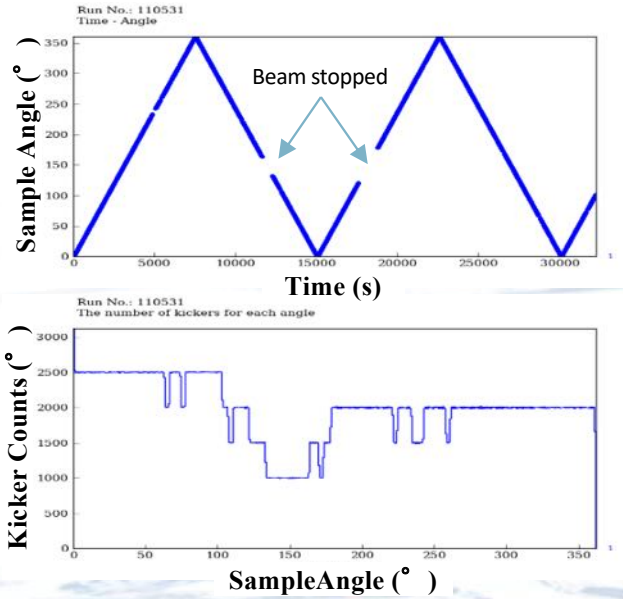
## New mode of 4D $S(Q, \omega)$ measurements for single-crystal comes into use

- **High flexibility compared to conventional *stepwise* rotation**
  - —No need to plan the step size or measurement time anymore. Just *RUN*!
- **Realized by taking advantage of the MLF event-recording system**

Analyses with different angle steps
(Angular slices *after* the measurement)




Monitoring the process




Long journey coming to an end?

Release of a prototype software
(Y. Inamura *et al.*, ICANS-XXII, 2017)

↓

Use by internal user program

↓

Goniometer unstable at some speeds

↓

Significant noise data from rotary encoder,
much higher than neutron data!

↓

A lot of bug fixes

↓

Use by general users (2022),
but errors in recorded angle data

↓

Replacement of the data acquisition computer

↓

**Re-start of use by general users (2025)**

# FUTURE PLAN

# MLF Roadmap : Moving Forward



M. Nakamura N. Kawamura

~2030

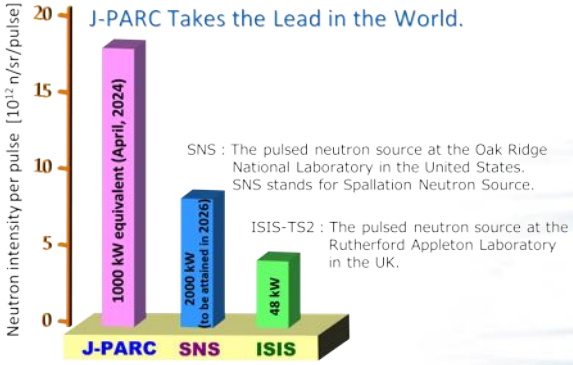
~2030s

Review current performance "MLF2030"

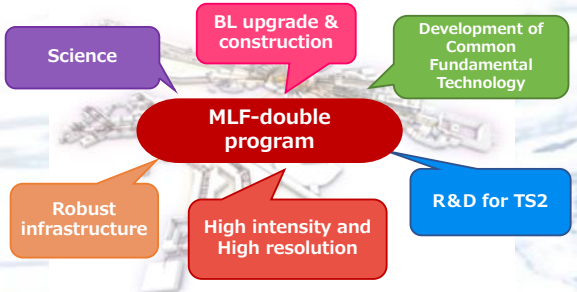
Upgrade planning of TS1 “MLF double”

Construction of TS2 and operation

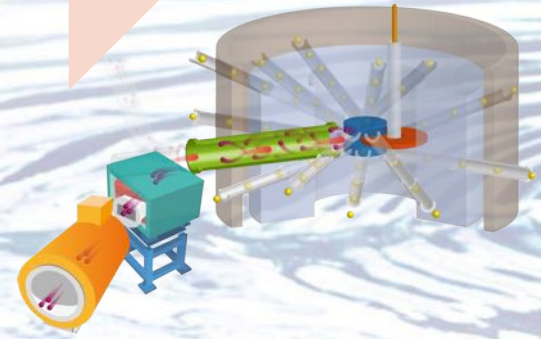
Highest flux/pulse achieved on TS1




Double the effectiveness of TS1: realize max use of TS1




TS2 > TS1* 20-100

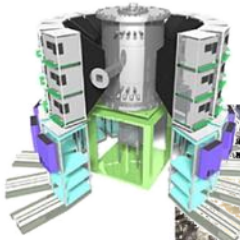


# MLF-double

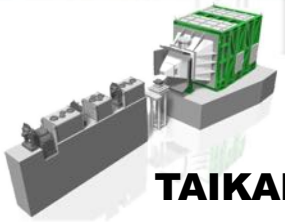

Aiming to double the effectiveness of TS1: realize max use of TS1

# MLF-double: Key Initiatives

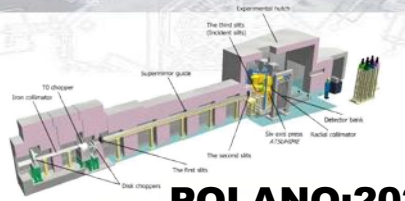




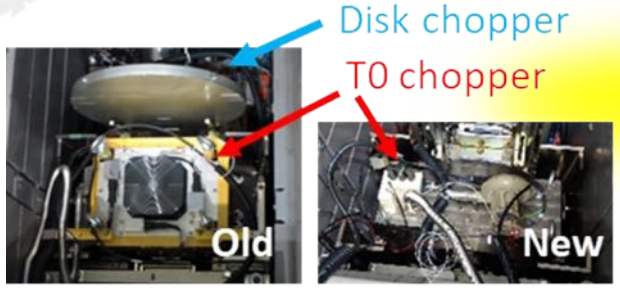
**SENJU: 2024~2026**

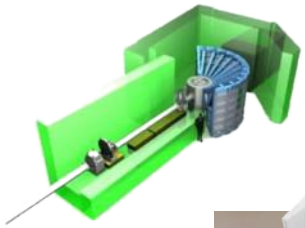
**TAIKAN:2025**



**POLANO:2026**

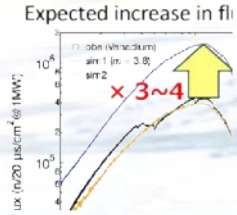



Replacement of the T0 chopper

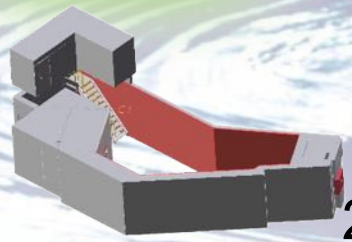


**SIKI**

**AMATERAS**

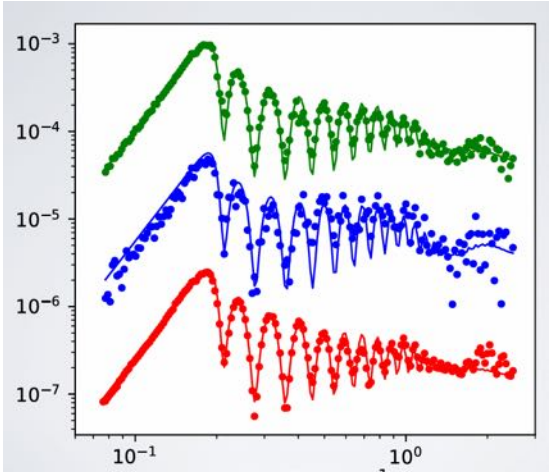

- Launch the Data Science Section
- Launch the MLF Improvement Strategy Office
- Pursue funding for the construction of a new beamline



# Information & Computation Science

## Denoise

✓ Denoising Artificial Neural Network




**measurement time**

normal

1/20

**1/20 & denoised**

**X10?**

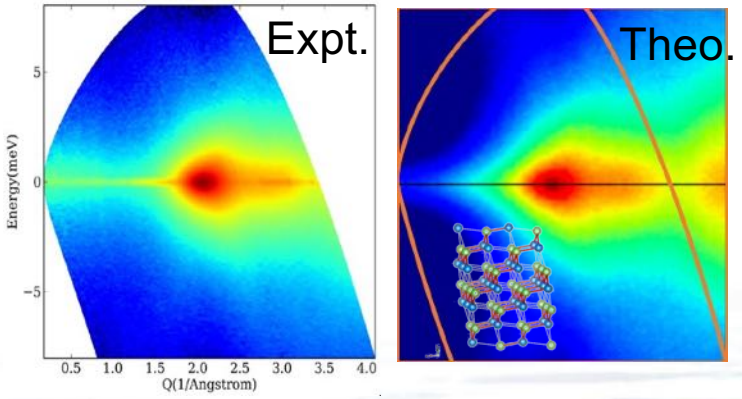
- Reflectometry (BL16, 17)

  Improve time resolutions
  Shorten a measurement time

- R&D for extention to other BL

## Non-emprical S(q, w) calculation

✓ Molecular Dynamics with Machine Learning Interatomic Potential



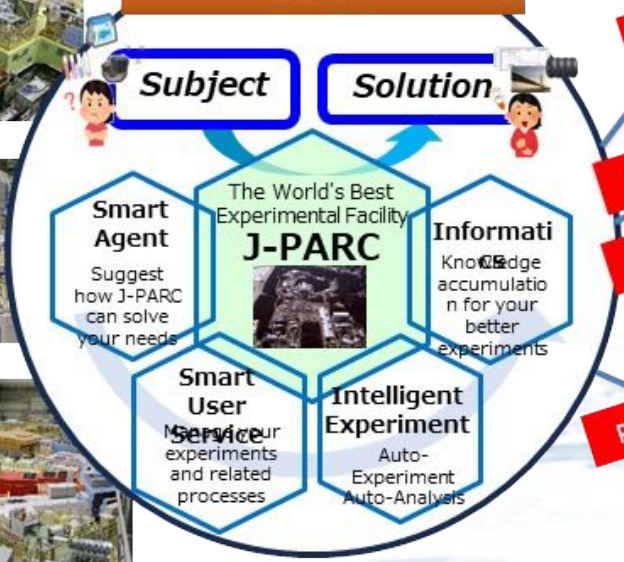

- Example of non-empirically obtained S(q, w) by performing MD calculations on the machine learning potential.
- Model-independent analysis done by data-driven science.

# J-PARC Integrated AI Platform – for Users

## J-IAP : J-PARC for your solution

*The World's best scientific opportunities offered to everyone!*

**J-IAP** – for Users
J-PARC Integrated AI Platform
"AI for Science" by J-PARC




Easy!

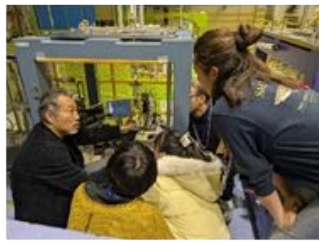
Faster!

Effective!

Productive!

### System A. AI Concierge

- Offering solutions to users' subjects based on knowledge of J-PARC.
- Support for creating and submitting users' proposals.
- Beamtime allocations without the proposal review committee through automated proposal review by AI.



### System B. Smart User Support

- Integrate J-PARC's databases of users, issues, experimental equipment, sample environments, chemicals, etc. to create a one-stop portal site for preparing experiments.
- Beamtime management functions automate beamtime allocation and consolidate usage records.

### System C. Intelligent Experiment Support

- Offering the best experimental plan emerged by knowledge of past experiences.
- Auto experimental execution.
- Auto data analysis by using Bayesian inference.

# MoU with Hitotsubashi Univ., May 2025

"Hitotsubashi University was established as a center of education and research embracing every field of the social sciences, which make up the learning of civil society."

Collaboration on data science

## Dean's Message

TOSHIAKI WATANABE

**To our prospective colleagues: pioneering the new academic field of Social Data Science**

We now live in what is often referred to as "the era of big data," where vast amounts of data are easily accessible. Big data has been dubbed "the oil of the 21st century," and data science, the field dedicated to extracting valuable information from such data, is gaining significant attention from society. The "social" in our "Social Data Science" program represents social sciences, including economics, business, law, politics, and sociology. In our program, students can comprehensively study the subjects related to data science, such as statistics, computer science, and artificial intelligence, alongside a wide range of social science subjects. Our faculty and graduate school are dedicated to advancing education and research in "Social Data Science," arised from the integration of social science and data science, to cultivate individuals capable of tackling new and emerging challenges in modern society. We welcome motivated students with diverse backgrounds to join us in exploring and pioneering new academic fields together.

## Faculty Members

| Social Science | Statistics | Information Science |
|---|---|---|
| NAOHIRO SHICHIJO<br>Science and Technology Policy, Computational Materials Science, Management of Technology | SUSUMU IMAI<br>Labor Economics, Industrial Organization, Applied Econometrics | MAMORU KOMACHI<br>Computational Linguistics, Natural Language Processing, Artificial Intelligence |
| MAYU TERADA<br>Advanced Technology and Law, Administrative Law, Information Law | CHIHIRO SHIMIZU<br>Index Number and Theory, Applied Econometrics, Economic Measurement | SHINSUKE SUZUKI<br>Neuroeconomics, Computational Neuroscience, Social Neuroscience, Computational Psychiatry |
| ATSUSHI HIYAMA<br>Human Augmentation, Virtual Reality, Gerontechnology | TOSHIAKI WATANABE<br>Financial Econometrics, Macroeconometrics, Bayesian Econometrics | ATSUSHI KEYAKI<br>Information Retrieval, Natural Language Processing, Dialogue Systems |
| YUJIN WOO<br>Political Science, International Relations | YOSHIMASA UEMATSU<br>Statistics, High-dimensional Data Analysis, Time Series Analysis | HARUAKI FUKUDA<br>Cognitive Science, Visual Perception, Cognitive Neuroscience |
| SUSUMU NAGAYAMA<br>Business Administration, Organization Theory, Creativity, Well-being | RYO KATO<br>Marketing Science, Bayesian Statistics, Missing Data Analysis | YOH-ICHI MOTOTAKE<br>Data Driven Science, Interpretable AI, Machine Learning |
| RYOHEI BANNO<br>Information Networks, Distributed Systems, IoT Systems | SHINICHIRO SHIROTA<br>Bayesian Statistics, Spatial/Spatio-temporal Statistics, Computational Statistics | TATSUYA YATAGAWA<br>Computer Graphics, Geometry Processing, Image and Video Processing |

## Access


Social Data Science

一橋大学 Hitotsubashi University

TEL+81-42-580-8000
2-1 Naka, Kunitachi, Tokyo 186-8601, Japan
https://www.hit-u.ac.jp/

# SOCIAL DATA SCIENCE

## Faculty of SDS
## Graduate School of SDS

**Solving issues in modern society through the "integration" of Social Science and Data Science**

In recent years,
significant changes in both our society and natural environment
have led to the emergence of various new problems worldwide,
and the circumstances surrounding these problems are constantly evolving.
To address the rapidly and unpredictably changing issues of modern society,
it is essential to identify and define appropriate problems,
collect and analyze the appropriate data,
and apply the obtained insights to enrich our life.
To achieve this goal,
our faculty and graduate school are committed to
promoting education and research in "Social Data Science."

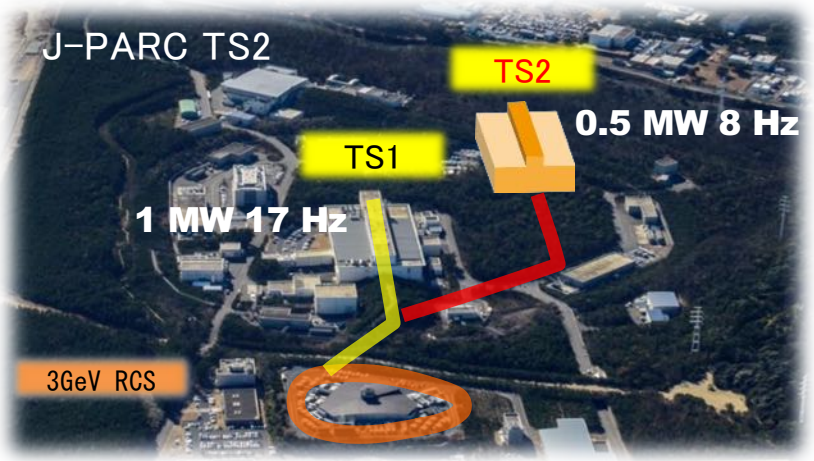
一橋大学 Hitotsubashi University

https://www.sds.hit-u.ac.jp/img/about/brochure-en.pdf

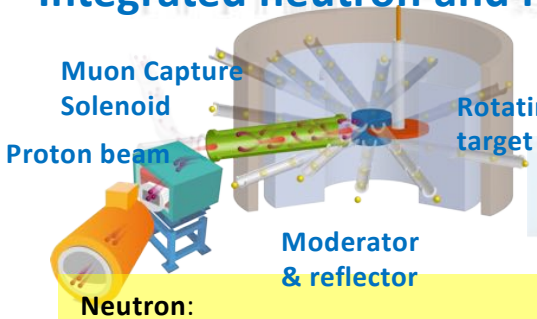
# Target Station - 2



World's first new target station (TS2) integrating neutrons and muons




## Integrated neutron and muon target

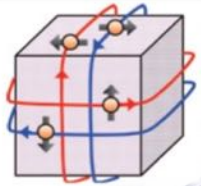



**Neutron**:
10 (target) x 2 (device) → 20 times gain of brightness

**Muon**: :
10 (target) x 5~10 (Muon capture solenoid) → 50 ~100 times gain of flux

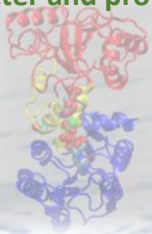
Science using the high-brilliance neutron/high-intensity muon at TS2

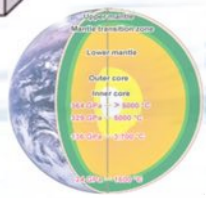
Polarized electron spin currents at the surface of a topological insulator



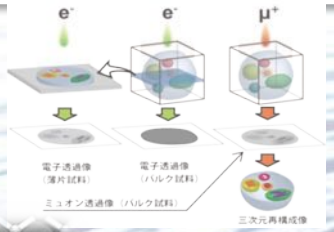
Neutron EDM
Muon EDM

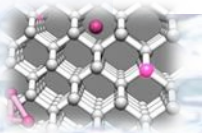
Dynamics of soft matter and proteins





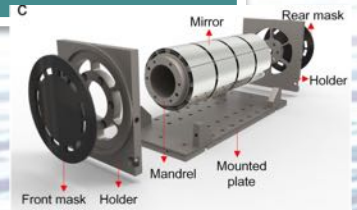
Structural analysis of the Earth's mantle

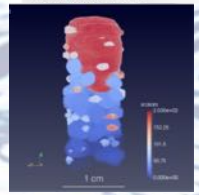




Cell Imaging

Structure around dopant (active site)



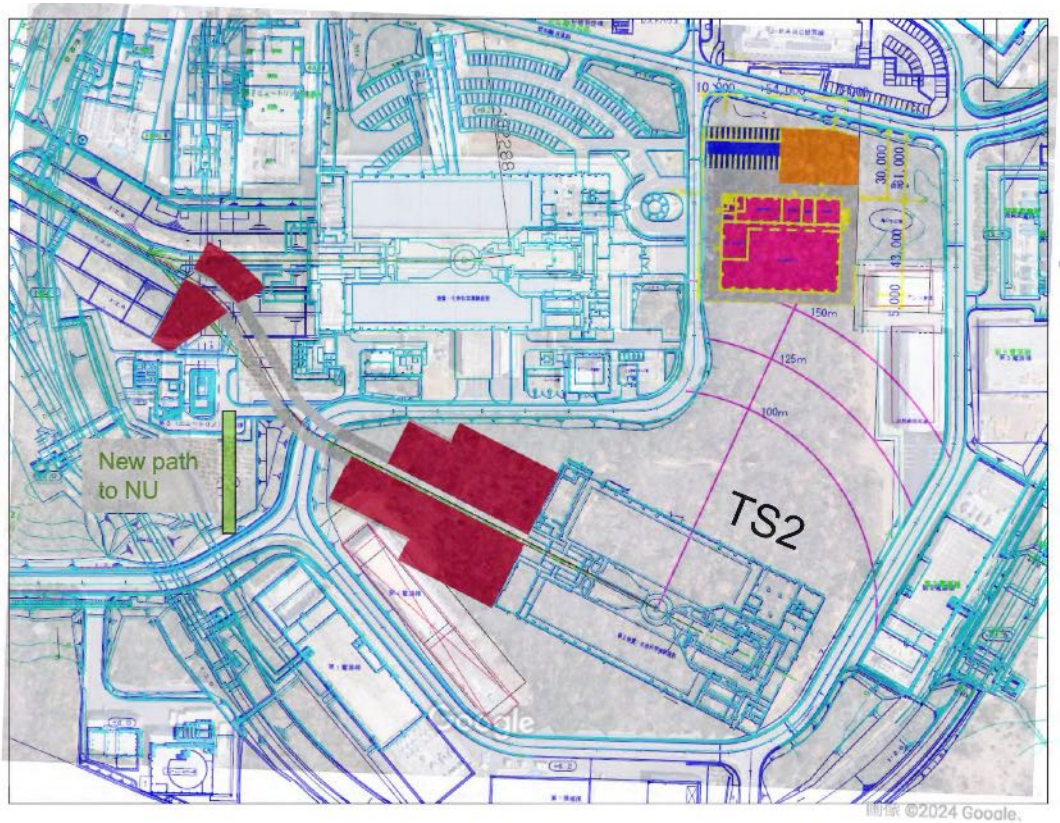



μm Imaging

Neutron diffraction imaging

# TS2 R&D

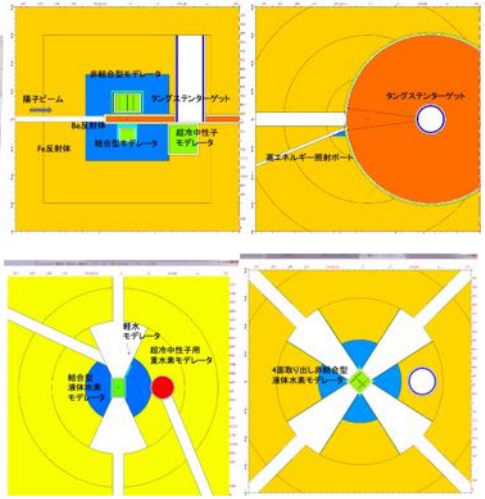




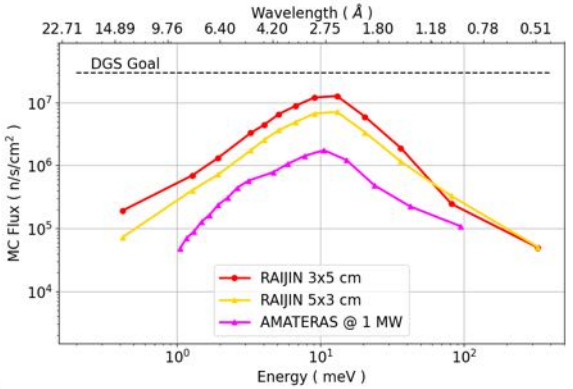

Composite on Google map

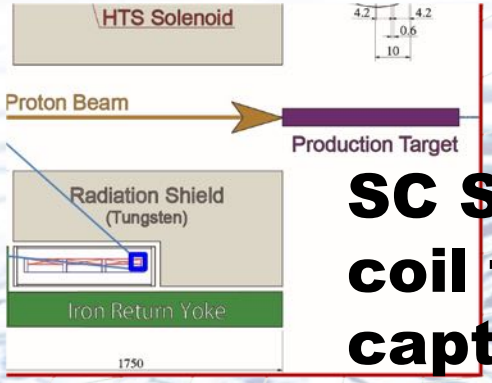
## Layout of TS2

## TMRA



## MC simulation of neutron spectrometer




## SC Solenoid coil for pion capture

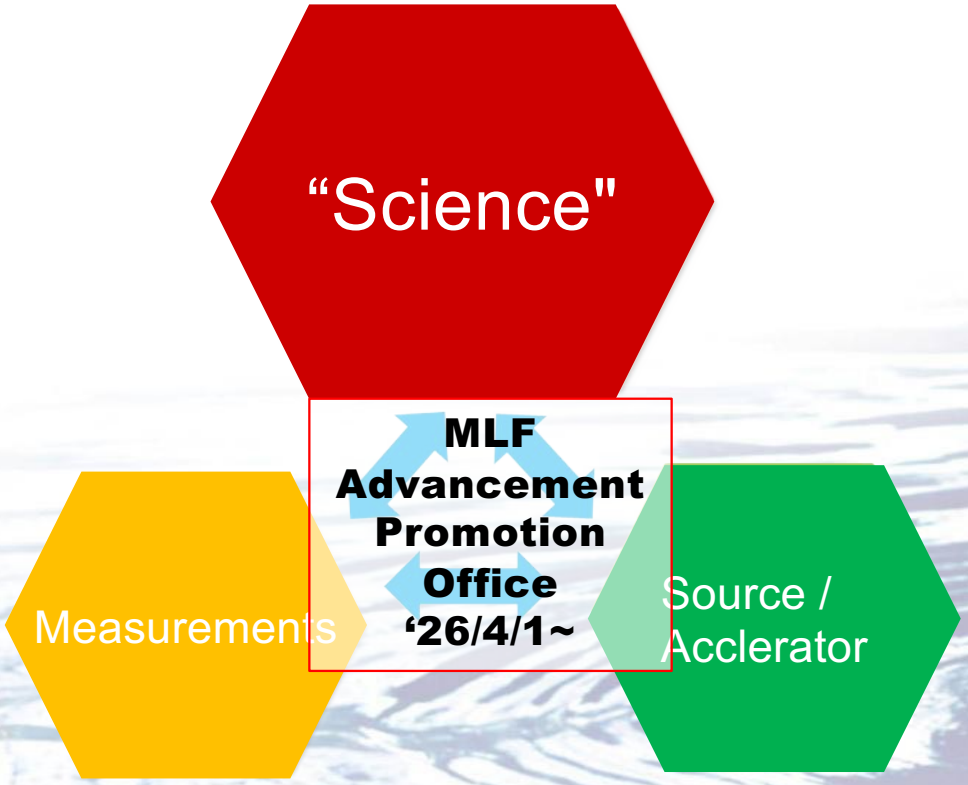
# How do the MLF roadmap should be established?

- Presenting the potential of MLF from the MLF side

- Discussion with the community
  - Science
  - Research and development of new methods and technologies
  - MLF Roadmap Workshop
    - Establishment of a working group

- Implement from the highest priority items
- Roadmap Updates

- **Domestic Workshops**
  - **Aug 26 2025**
  - **March 14 2026**



# Summary

- MLF user program suspended by unexpected outage of the neutron target system in 2024 and 2025.
  - Leakage of Hg-pipe seal and cooling water pipe.
- Currently MLF operated at 810 kWeq.
  - We expect that 2-years operation with the single vessel.
- MLF published highly-cited paper of material science, engineering and geo-science.
  - The number of highly cited publications of MLF is on the rise.
- Discussion of the MLF roadmap has been started with the Japanese community.
  - Upgrade of TS1 instruments are on-going as "MLF-double" program.
  - Work on TS2 is under way.