Phase-transition in Fusion Research

--- first order, or second order ?

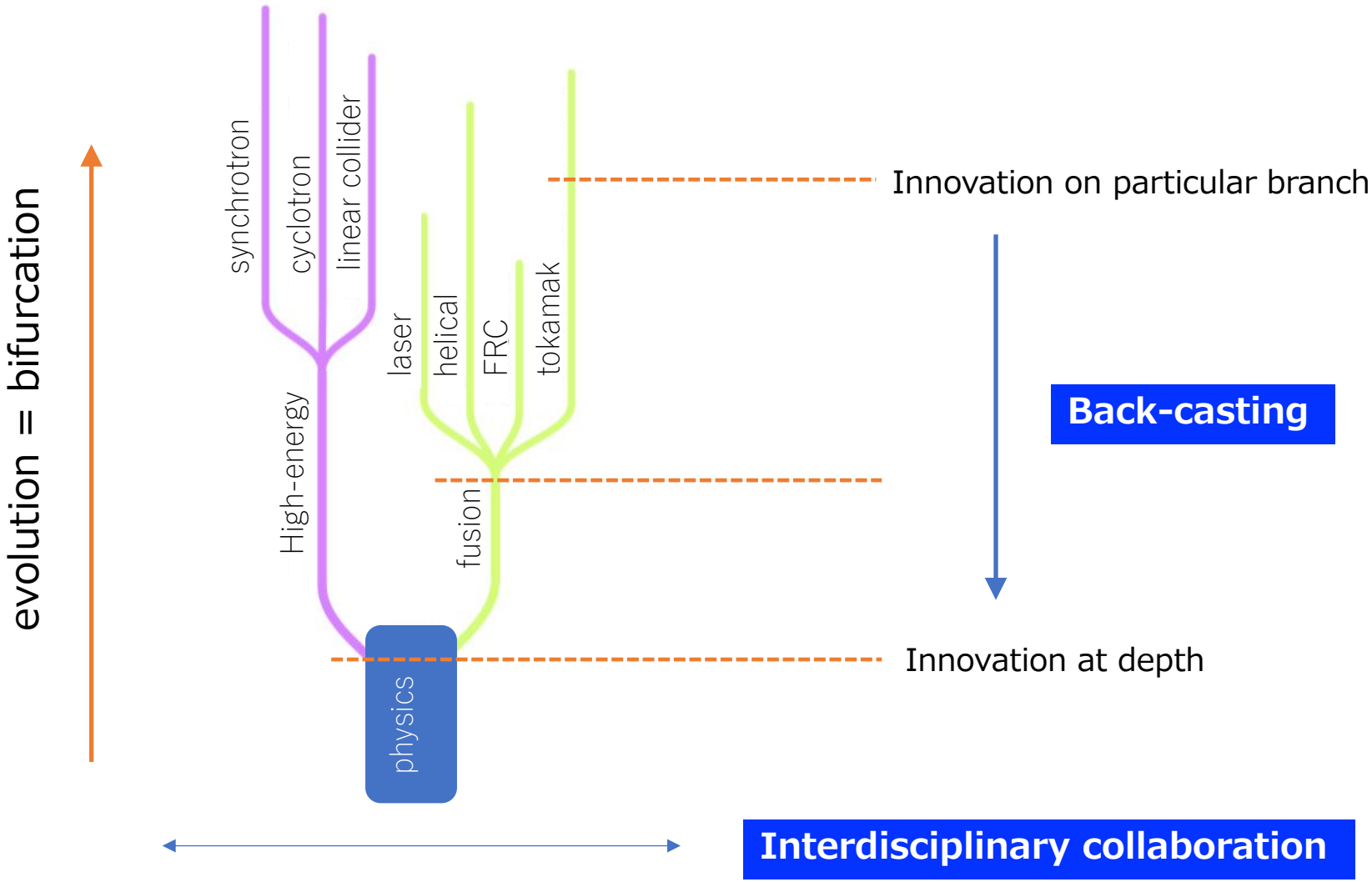
Zensho Yoshida

National Institute for Fusion Science (NIFS)

Key issues in the phase transition

- INTERDISCIPLINARY collaborations for expanding the fusion community
- SEGMENTATION of “fusion” for formulating advanced meaning of science and technology, realizing diverse collaborations with a wide range of disciplines
- PARADIGM-SHIFT from “machine-oriented study” to “subject-oriented study”

Interdisciplinary Collaboration by Back-Casting Approach



Segmentation & Generative Grammar

itswhatmakesarose

A sequence of “symbols” (sounds)
--- an abstract set of elements

segmentation

[it][‘s][what][makes][a][rose]

A sequence of “words”
--- extracting units of concepts

composition

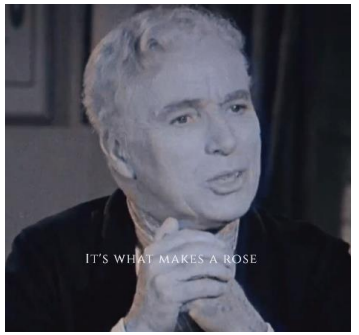
It’s what makes a rose.

A “sentence”
--- generating a concrete meaning

composition

Terry: all life is aimless, without meaning.
Calvero: what do you want a meaning for?
Life is a desire, not a meaning. Desire is the theme of all life! It’s what makes a rose. · ·

A “text”
--- generating a real meaning



Charles Chaplin
in “Limelight”

Segmentation & Generative Grammar

itswhatmakesarose

A sequence of “symbols” (sounds)
--- an abstract set of elements

segmentation

[it][‘s][what][makes][a][rose]

A sequence of “words”
--- reading out units of meaning

It’s what makes a rose.

Unlimited possibilities
of compositions

Gather roses while you may.

But it’s been no bed of roses.

Segmentation & Generative Grammar

itswhatmakesarose

A sequence of “symbols” (sounds)
--- an abstract set of elements

segmentation

[it][‘s][what][makes][a][rose]

A sequence of “words”
--- reading out units of meaning

It’s what makes a rose.

Unlimited possibilities
of compositions

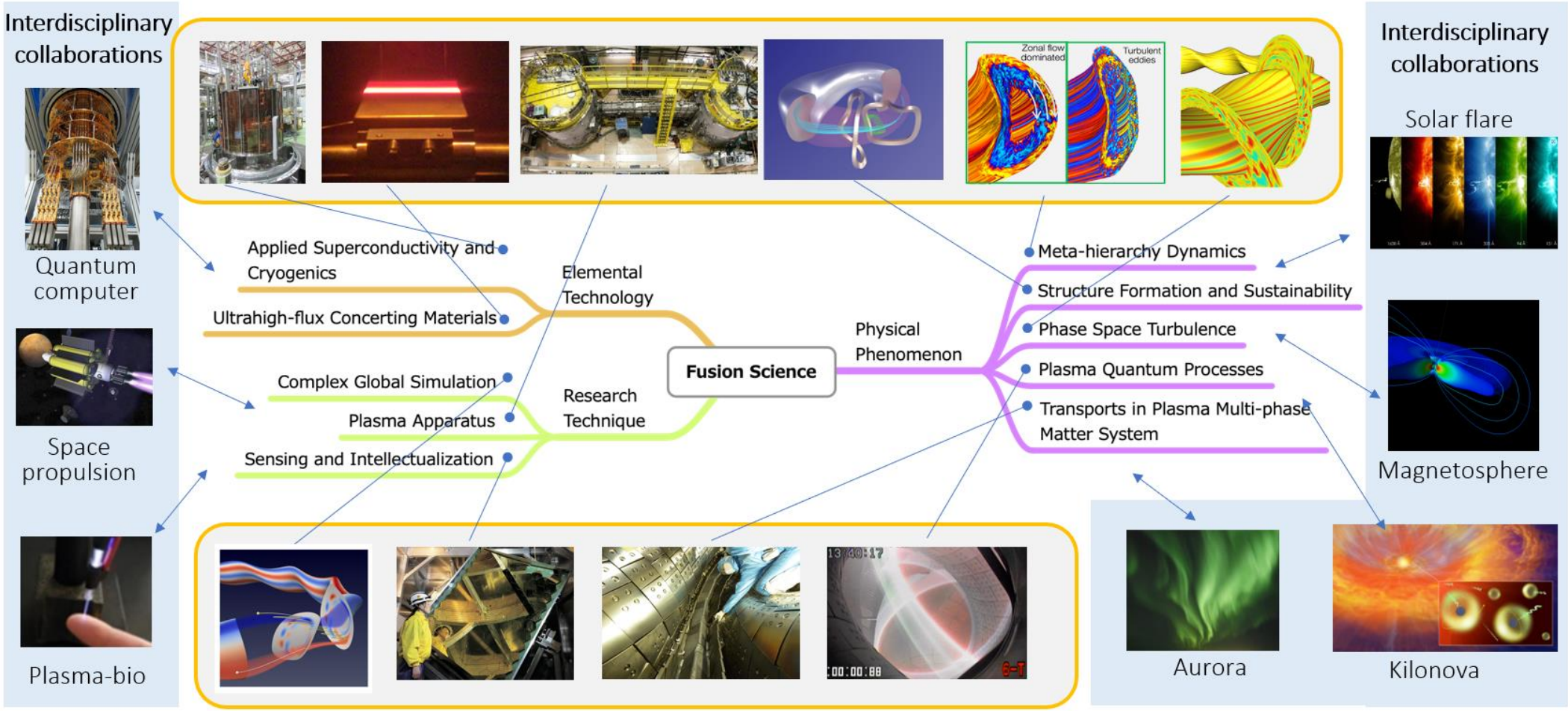
But, thinking makes it so.

What does not destroy me,
makes me stronger.

Segmentation

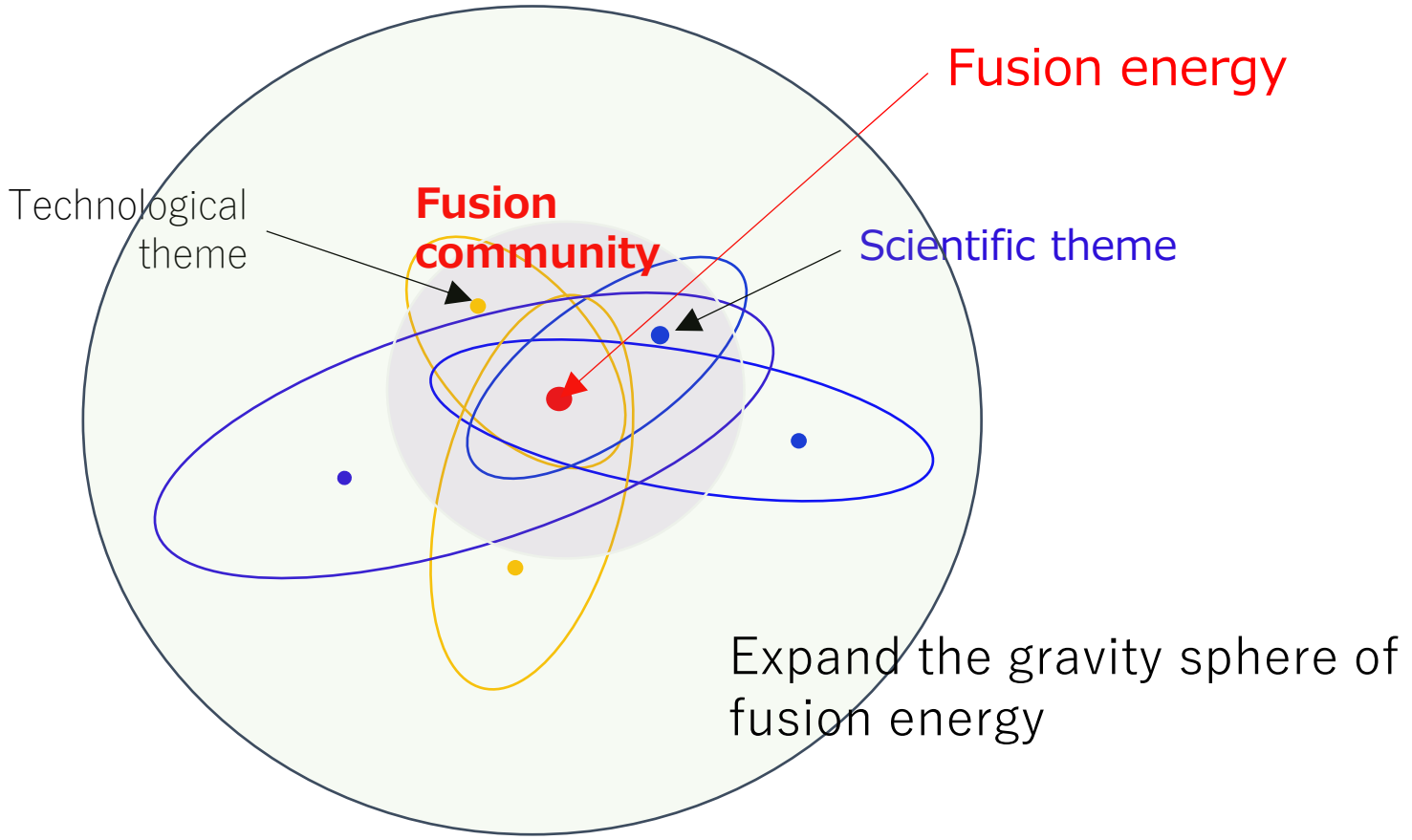
→ “Unit Vectors” spanning the phase space of fusion science

“Unit system” consisting of rhizomes, penetrating into a wide range of modern science and technology



Segmentation

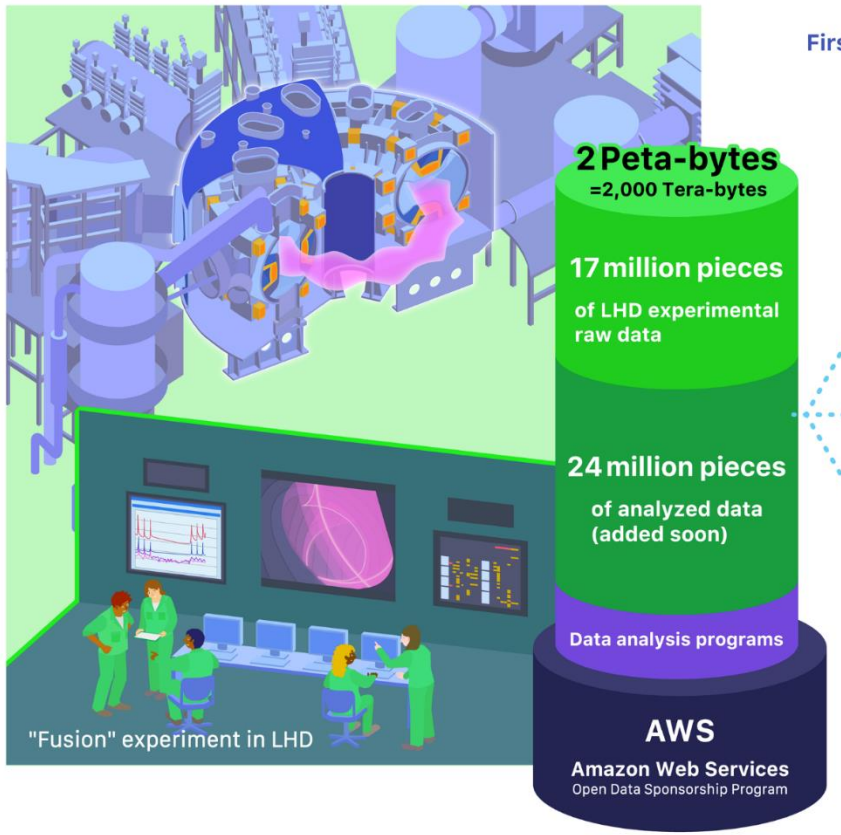
→ expansion of the gravity sphere of fusion research

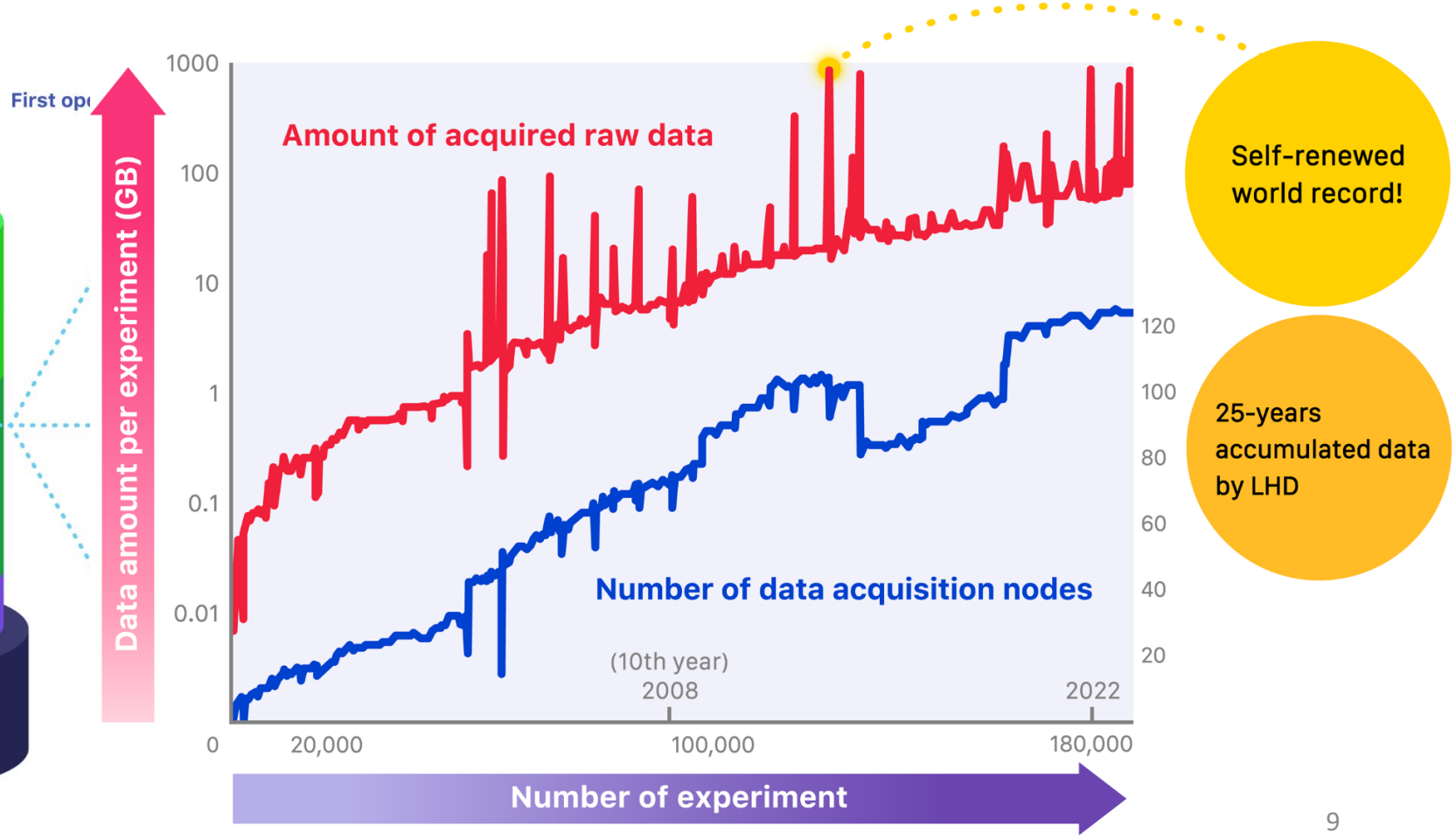


Open science strategy for creating a nodal point

NIFS LHD is a huge data silo … growing steadily

- LHD's 130 diagnostic & 1,000 analyzed data are "open", no embargo to be Findable, Accessible, Interoperable, and Reusable …





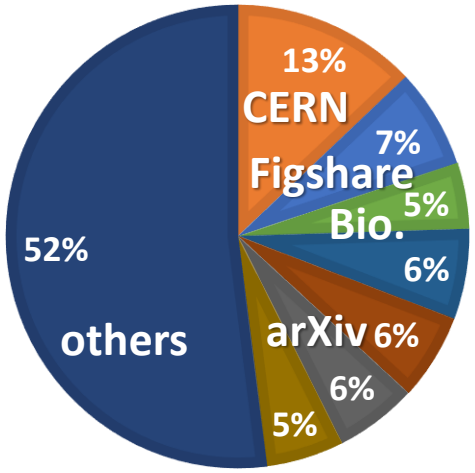
Open science strategy for creating a nodal point

NIFS LHD is a huge data silo … growing steadily

- NIFS registered 10,000,000 DOIs on LHD diagnostic data in 2024
- First time over 10 million DOIs in multidisciplinary sciences

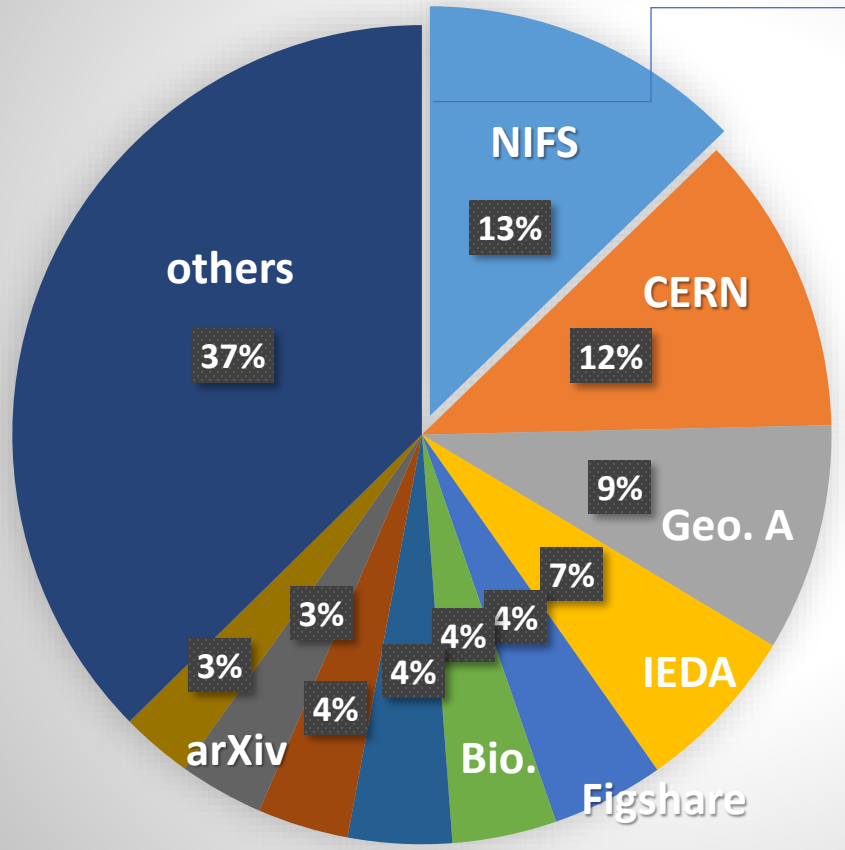
Lead the world together with other fields into “Open Science”

DEC. 2022
TOTAL: 37,989,719



double!

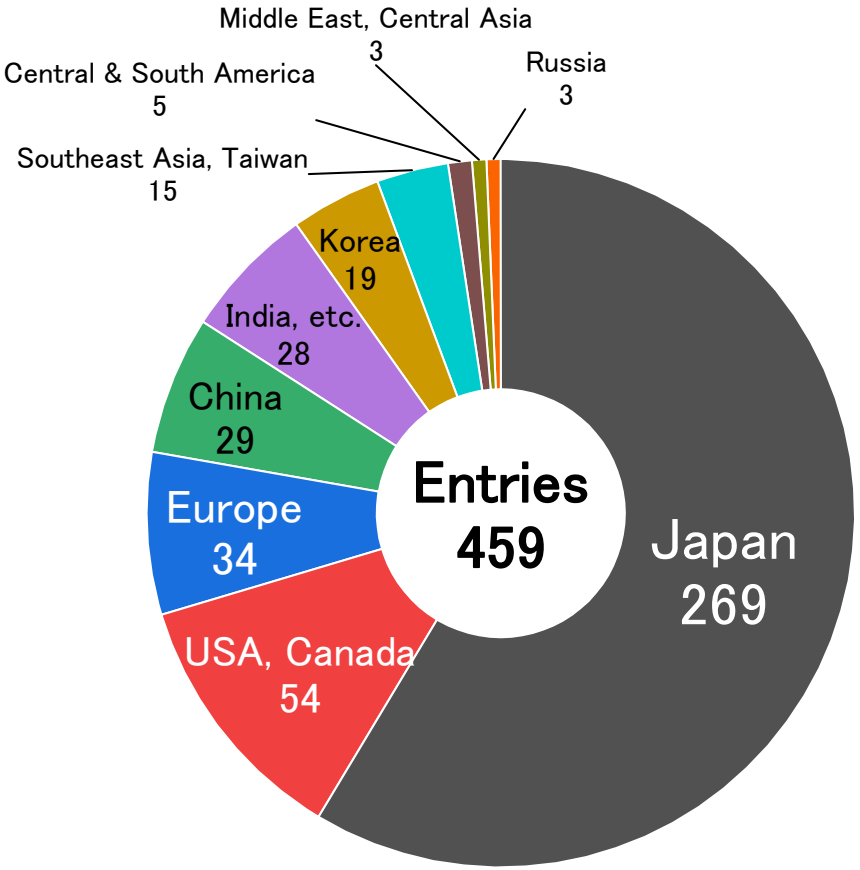
DEC. 5, 2024
Total: 78,309,037



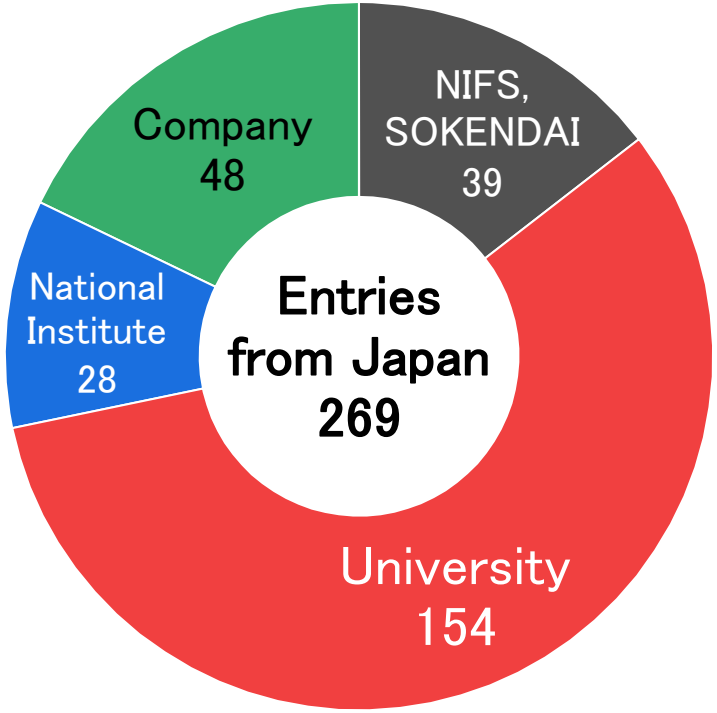
National Institute for Fusion Science
CERN - European Organization for Nuclear Research
Geoscience Australia
Interdisciplinary Earth Data Alliance (IEDA)
Figshare Internal
Global Biodiversity Information Facility

IIS2024 Total Entries

Entries by Country

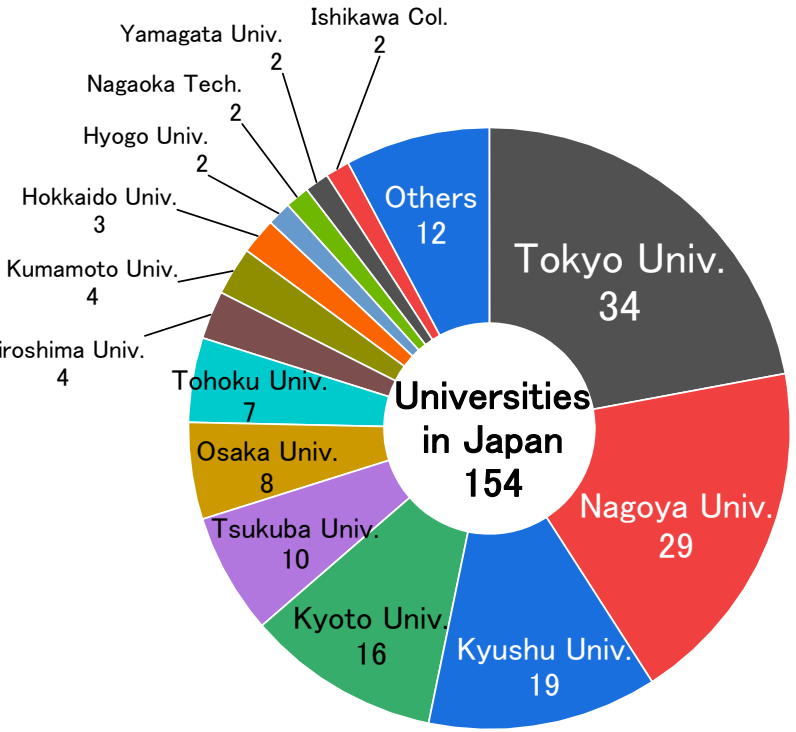


Entries by industry sector in Japan

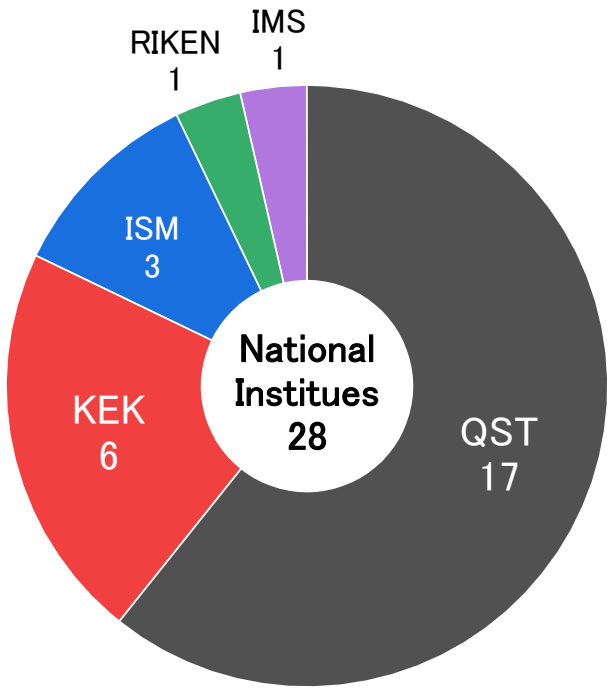


IIS2024　Entries by industry in Japan

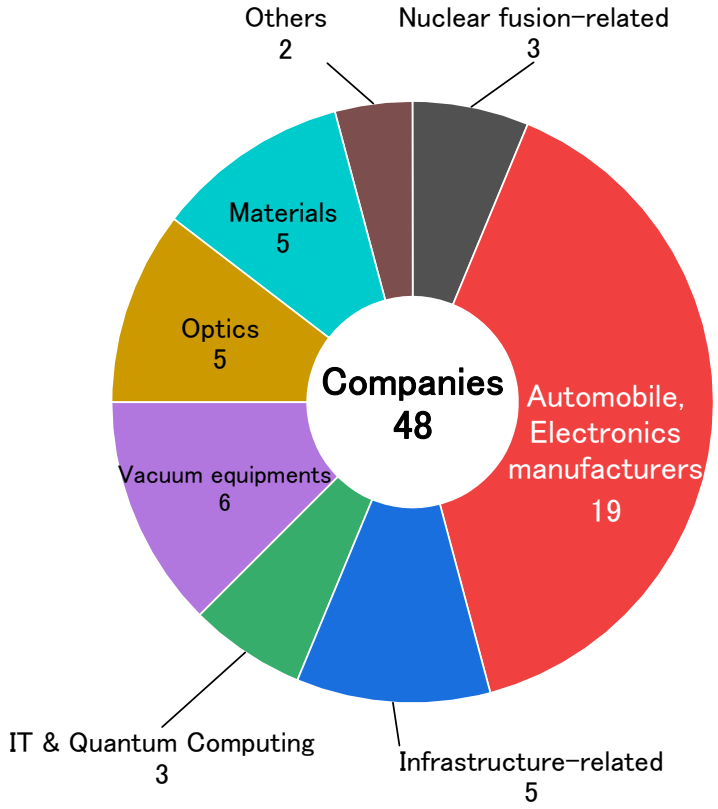
University



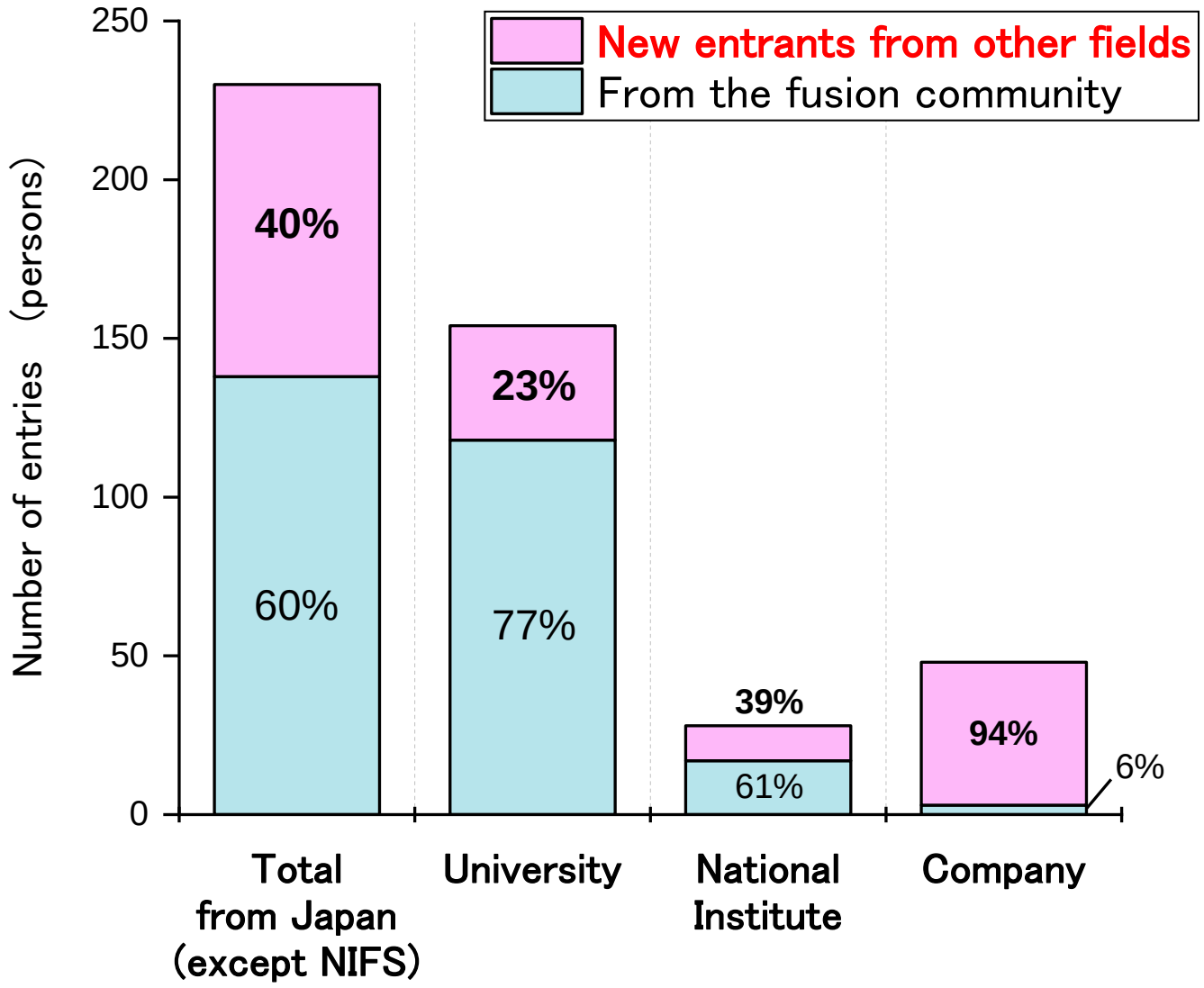
National Institute



Company

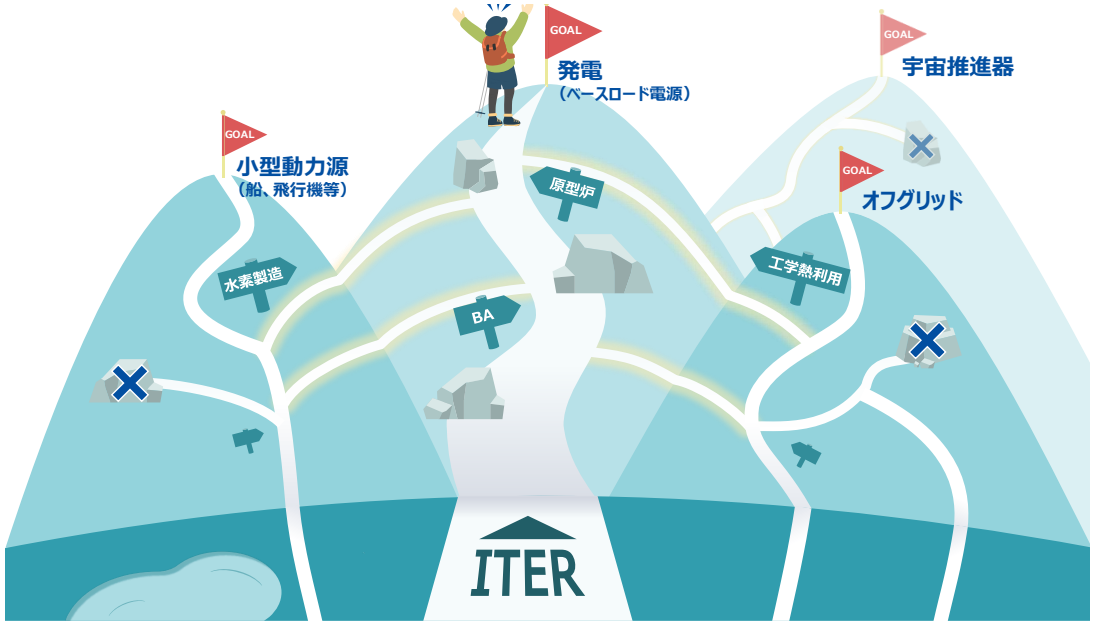


IIS2024　Percentage of new entrants in Japan



Paradigm-shift for inclusive strategy

From “fore-casting” approach to “back-casting” approach



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Paradigm-shift for the evolution of fusion study

dawn → early growth stage → development phase

Learn from star's mechanism

Competition among various systems

Cambrian explosion

Can't understand anything without prototype

Experimental proof of thermonuclear reaction

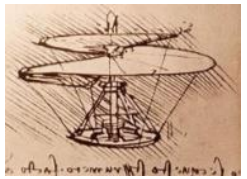
ITER

Matured level of segmentation into interdisciplinary subjects of studies

Ex : aircraft innovation and fluid mechanics

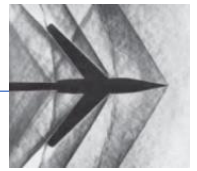
Learn from nature

Various ideas



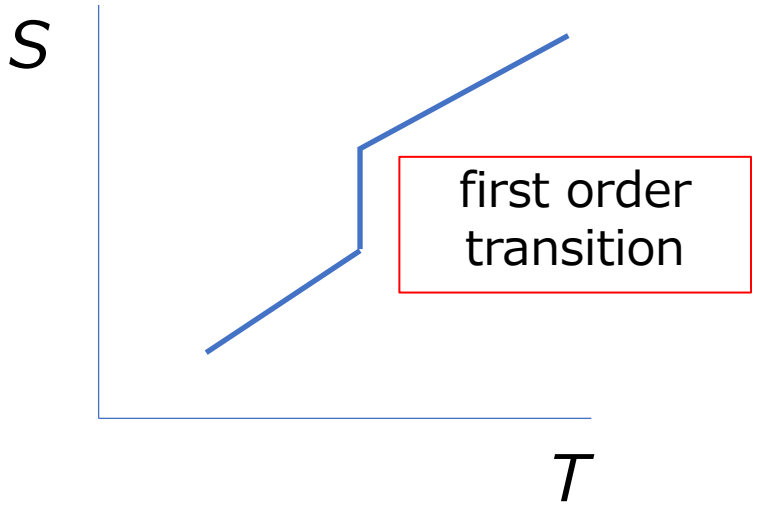
Wright Flyer

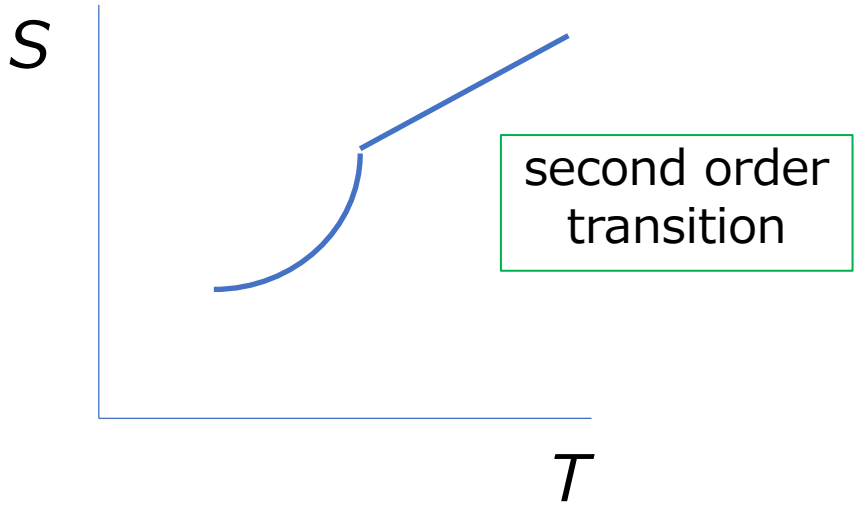
Collaboration between science and technology

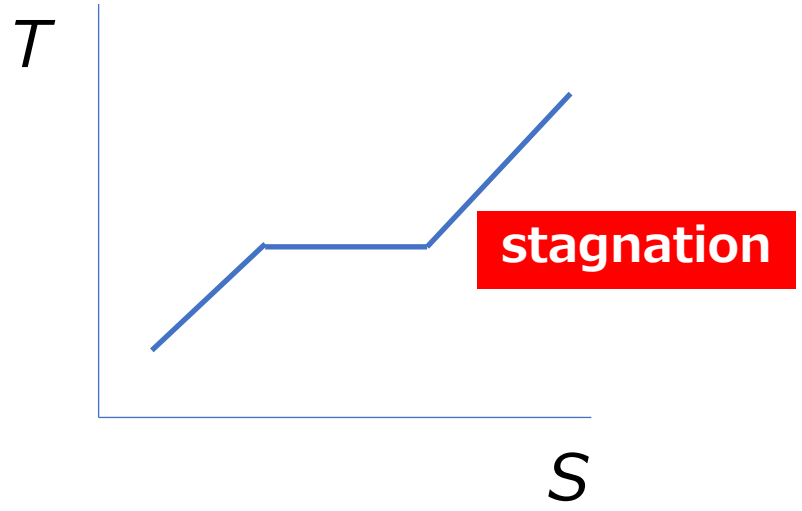


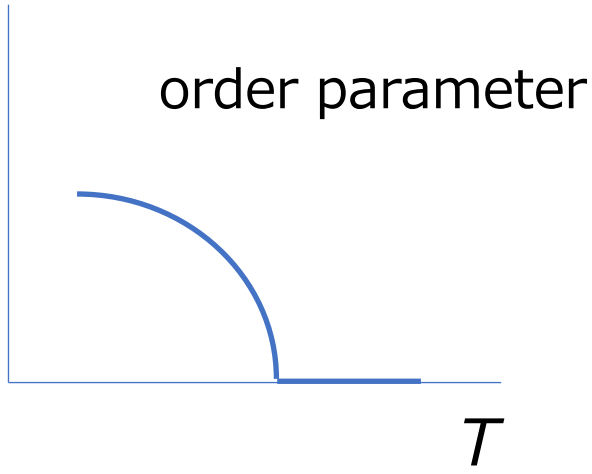
Basic science drives innovation

Q: How can we make the phase transition *second order* ?



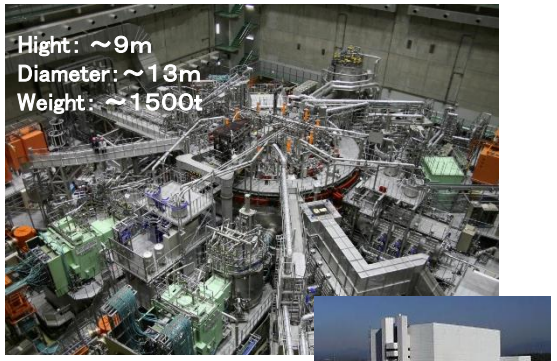






NIFS: platform for advanced studies open to international/interdisciplinary collaborators

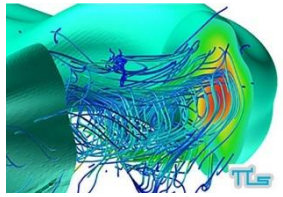
Large Helical Device (LHD)



- One of the world's largest superconducting plasma experimental devices
- Various physics research utilizing steady, high-precision magnetic fields
- World's most accurate measurement devices to elucidate the internal structure of plasma → Experimental research on all phenomena in the universe

Plasma Simulator "Raijin"

- The supercomputer "Raijin" in the HPCG benchmark (performance index),
  -3rd in Japan, 10th in the world (November 2020)
  -5th in Japan, 13th in the world (June 2021)
- Elucidation of complex phenomena in fusion core plasma
- Elucidation of cosmic and astronomical phenomena including nuclear fusion



Core Testing Facilities for Fusion Engineering

13 T, ϕ700 mm Solenoid Coil

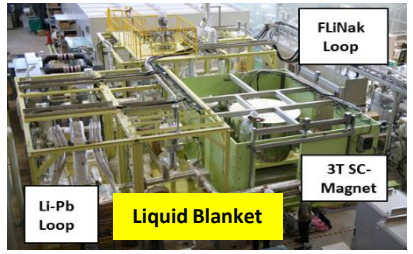
Temperature Variable Helium Refrigerator

Superconducting Magnet

High-Temp, High-Vacuum Creep Test Facilities

Hot Isostatic Press (HIP)

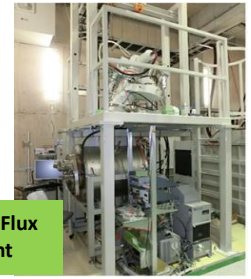
Advanced Materials



Li-Pb/FLiNaK Twin-Loop with 3 T Superconducting Magnet (Oroshhi-2)

Tandem Accelerator for Ion Beam Surface Analysis

High Heat Flux Component



High Heat Flux Testing Facility (ACT2)

- Developing advanced technologies for advanced fusion reactor systems
- Developing a wide range of engineering collaborations with universities