

Phase-transition in Fusion Research

--- first order, or second order ?

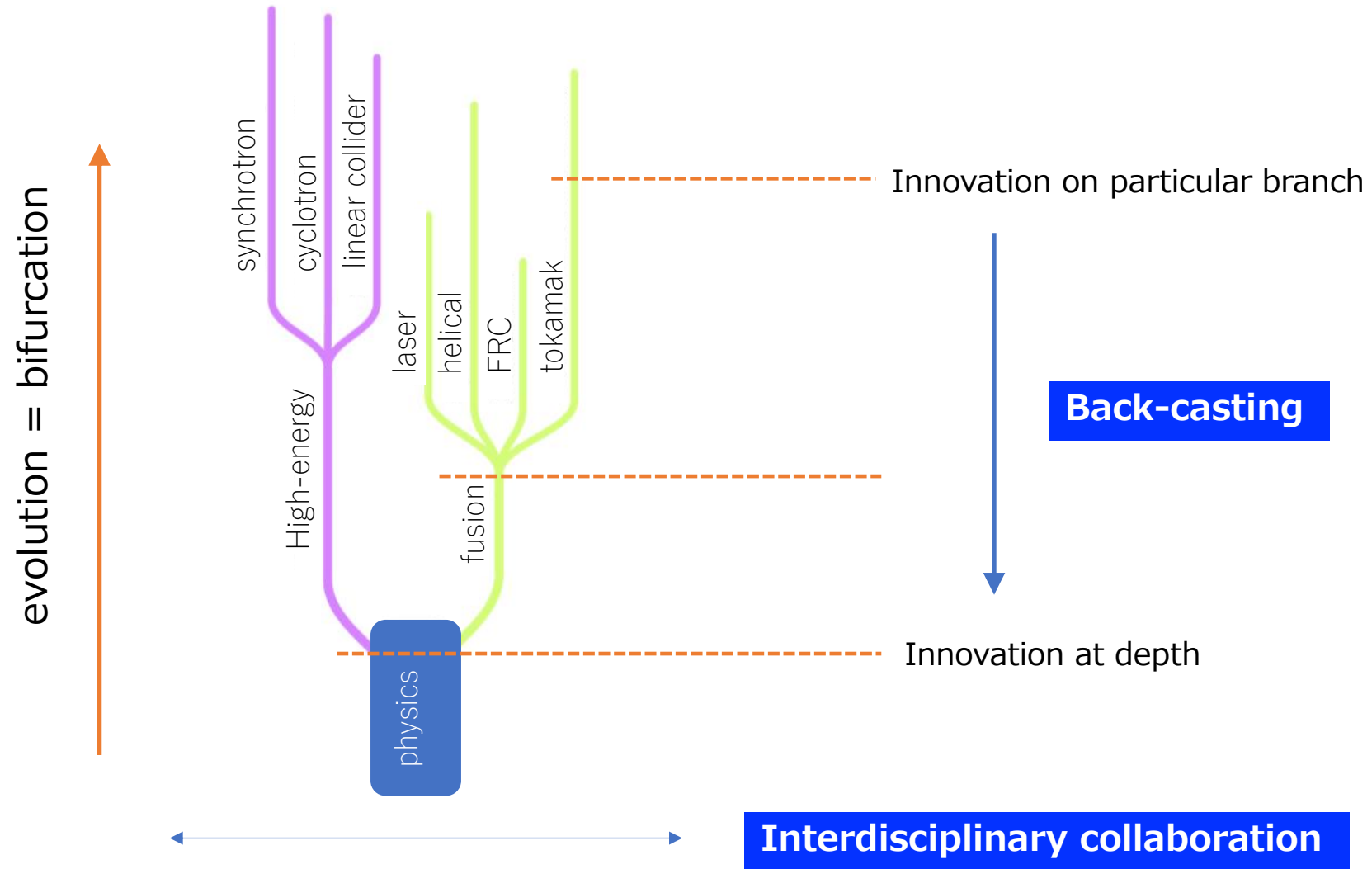
Zensho Yoshida

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



segmentation

[it]['s][what][makes][a][rose]



composition

It's what makes a rose.



composition

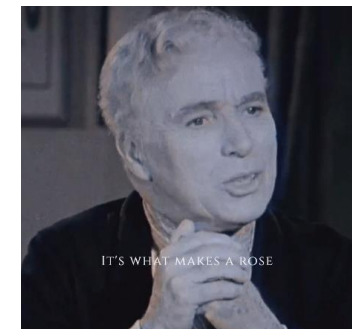
Terry: all life is aimless, without meaning.
Calvero: what do you want a meaning for?
Life is a desire, not a meaning. Desire is the
theme of all life! It's what makes a rose. . .

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

A sequence of "words"
--- extracting units of concepts

A "sentence"
--- generating a concrete meaning

A "text"
--- generating a real meaning



Charles Chaplin
in "Limelight"
4

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

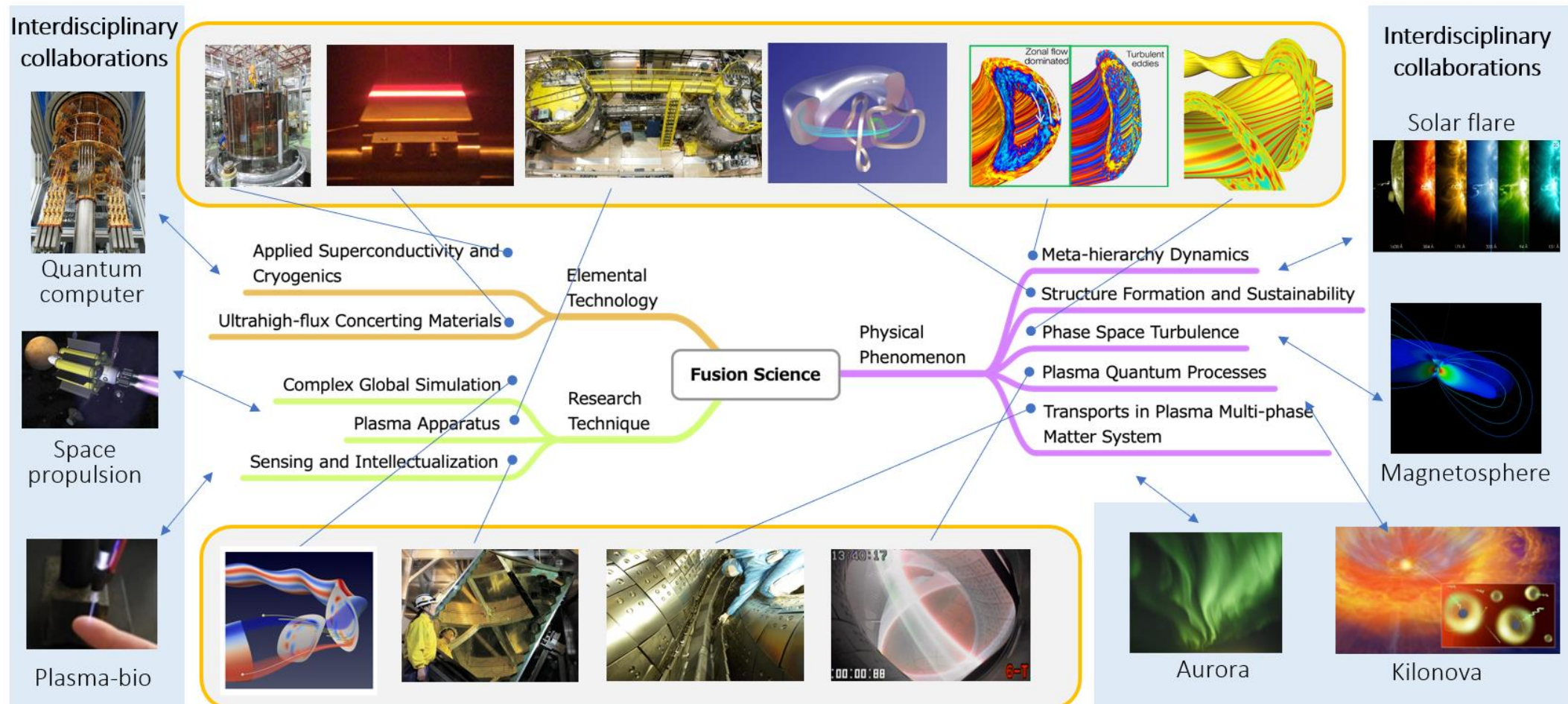
But, thinking makes it so.

What does not destroy me,
makes me stronger.

Segmentation

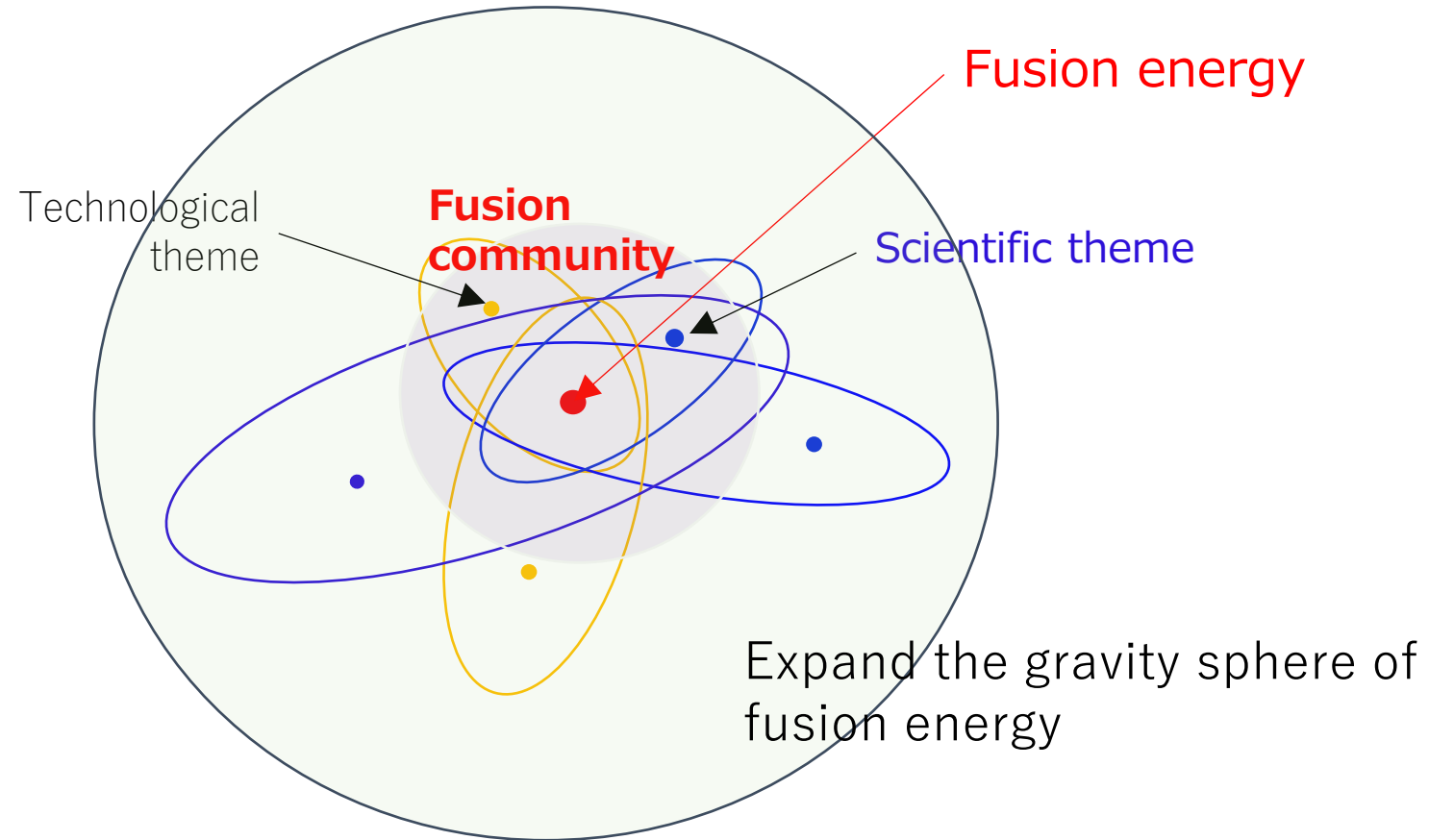
→ “Unit Vectors” spanning the phase space of fusion science

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



Segmentation

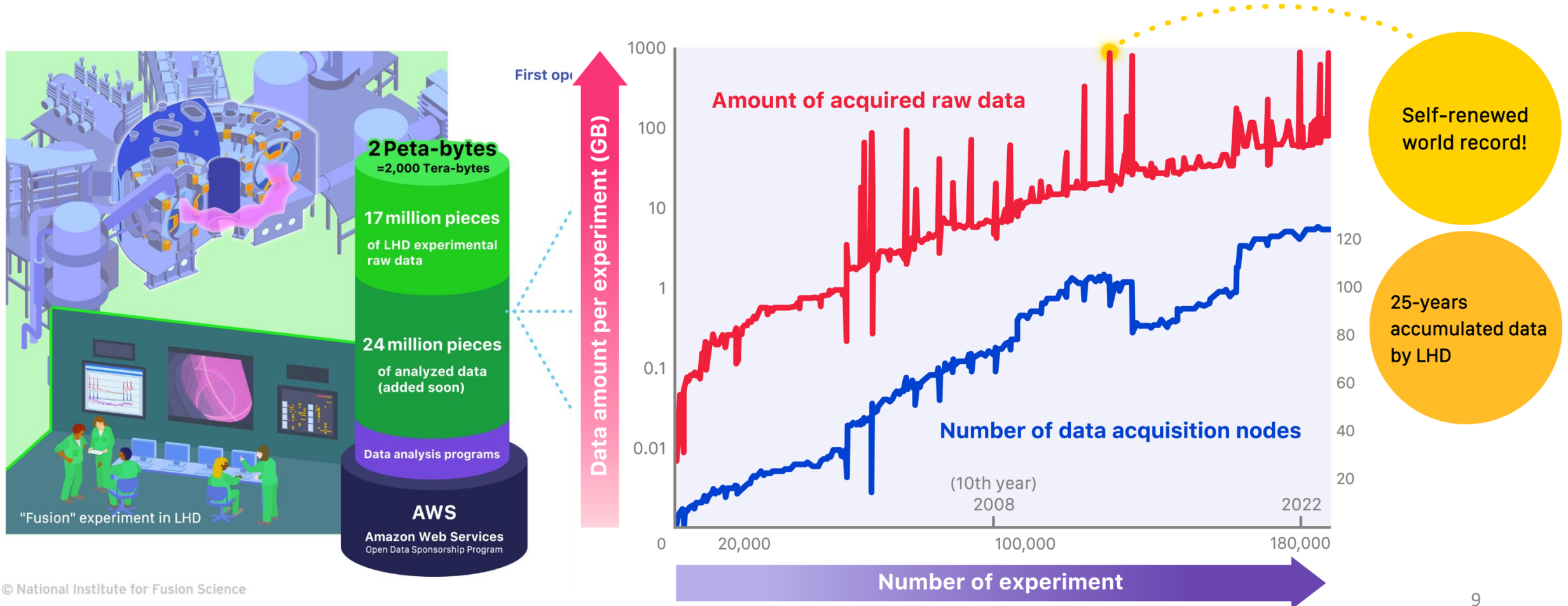
→ expansion of the gravity sphere of fusion research



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 ...



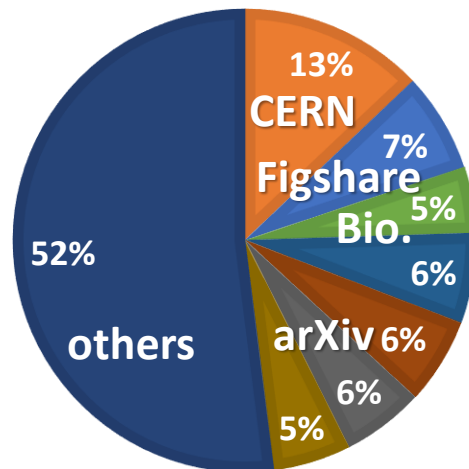
Open science strategy for creating a nodal point

NIFS LHD is a huge data silo ... growing steadily

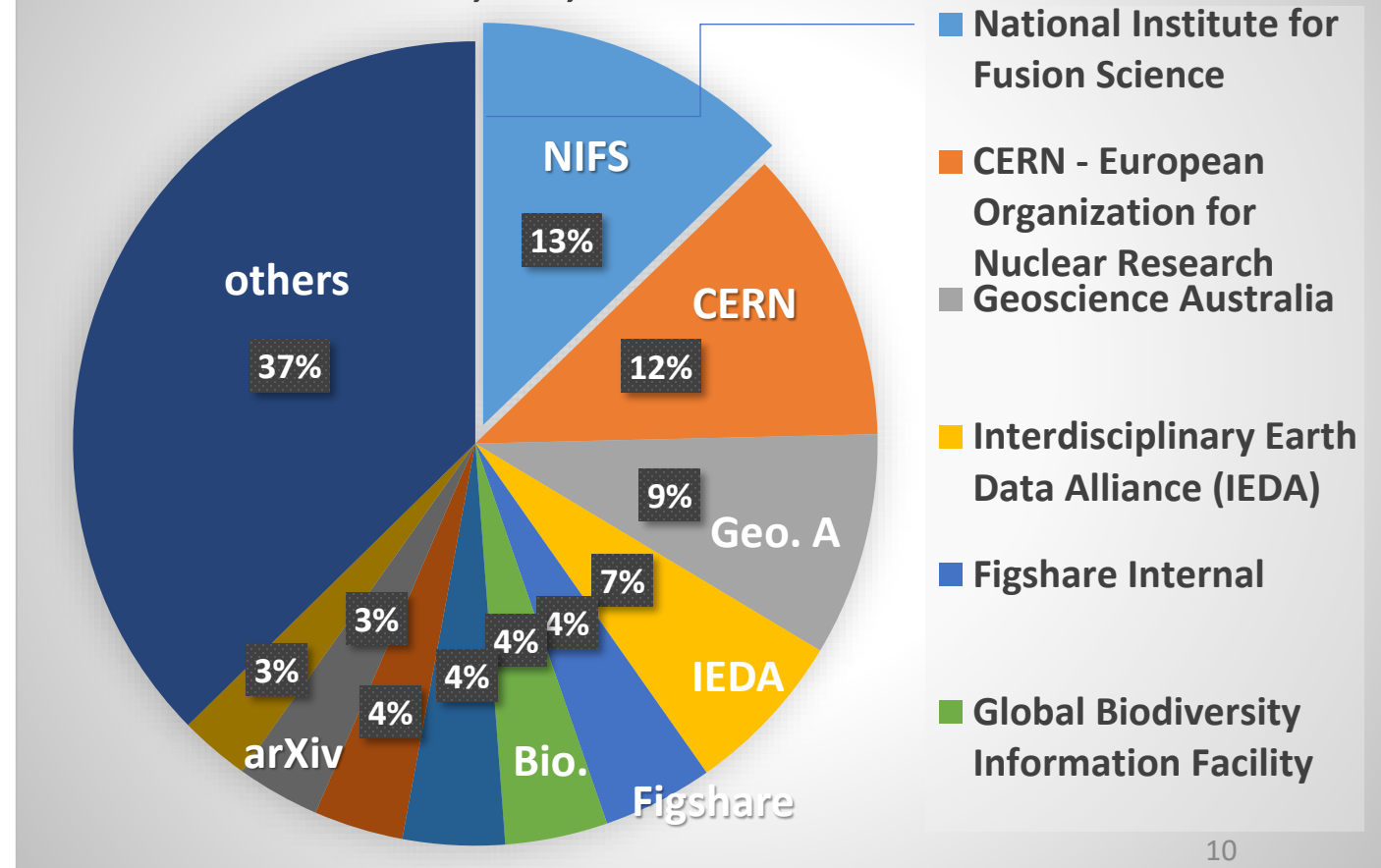
- NIFS registered 10,000,000 DOIs on LHD diagnostic data in 2024
- First time over 10 million DOIs in multidisciplinary sciences

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

DEC. 2022
TOTAL: 37,989,719

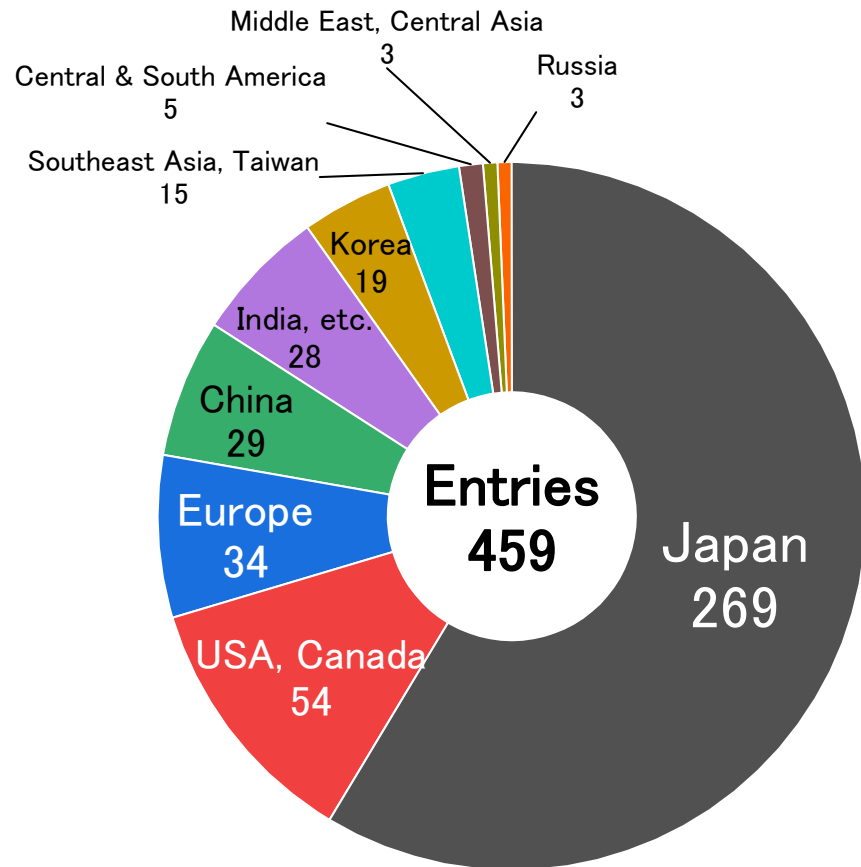


DEC. 5, 2024
Total: 78,309,037

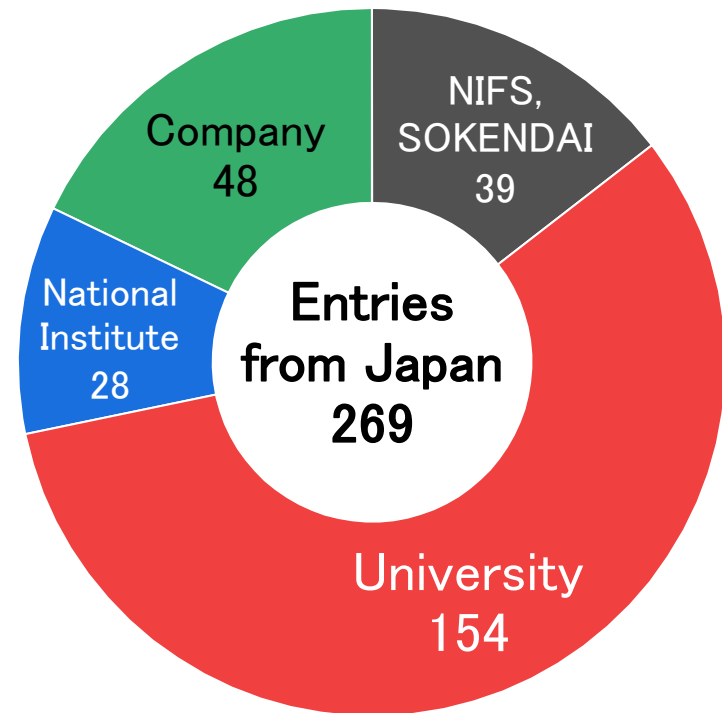


IIS2024 Total Entries

Entries by Country

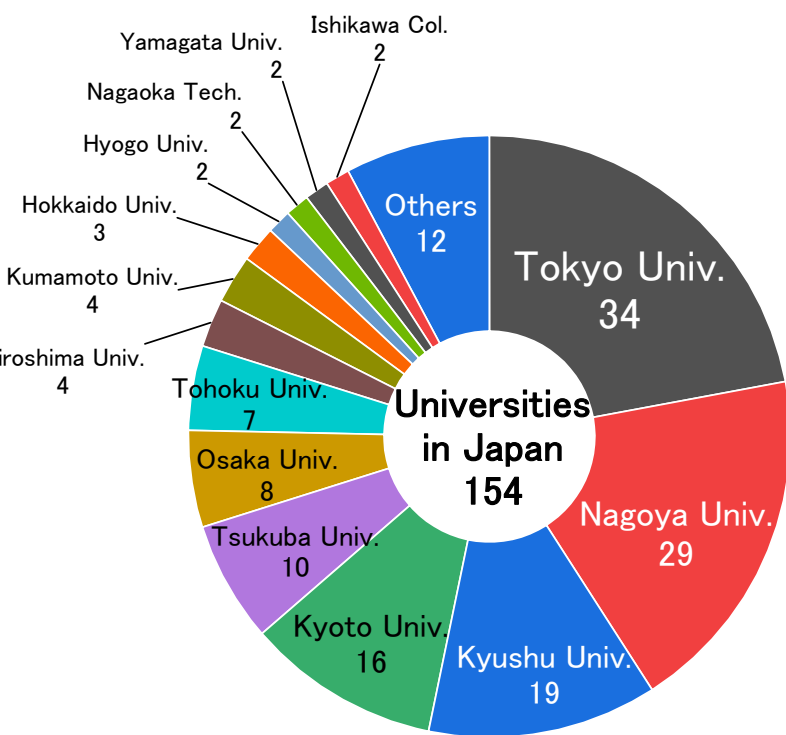


Entries by industry sector in Japan

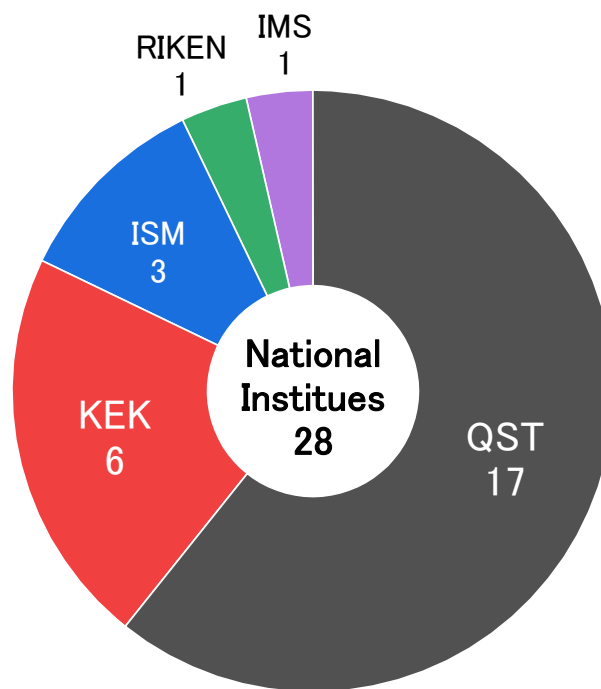


IIS2024 Entries by industry in Japan

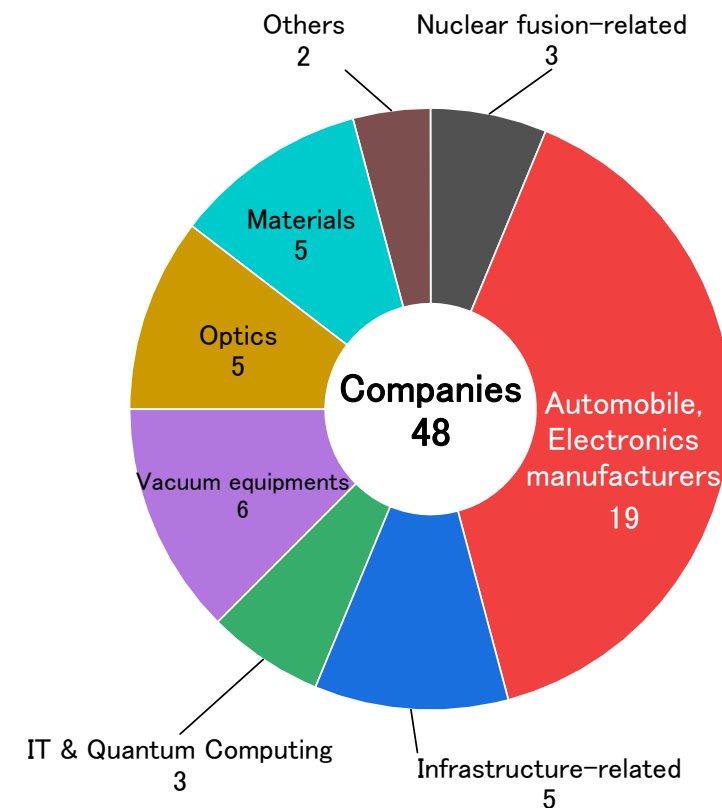
University



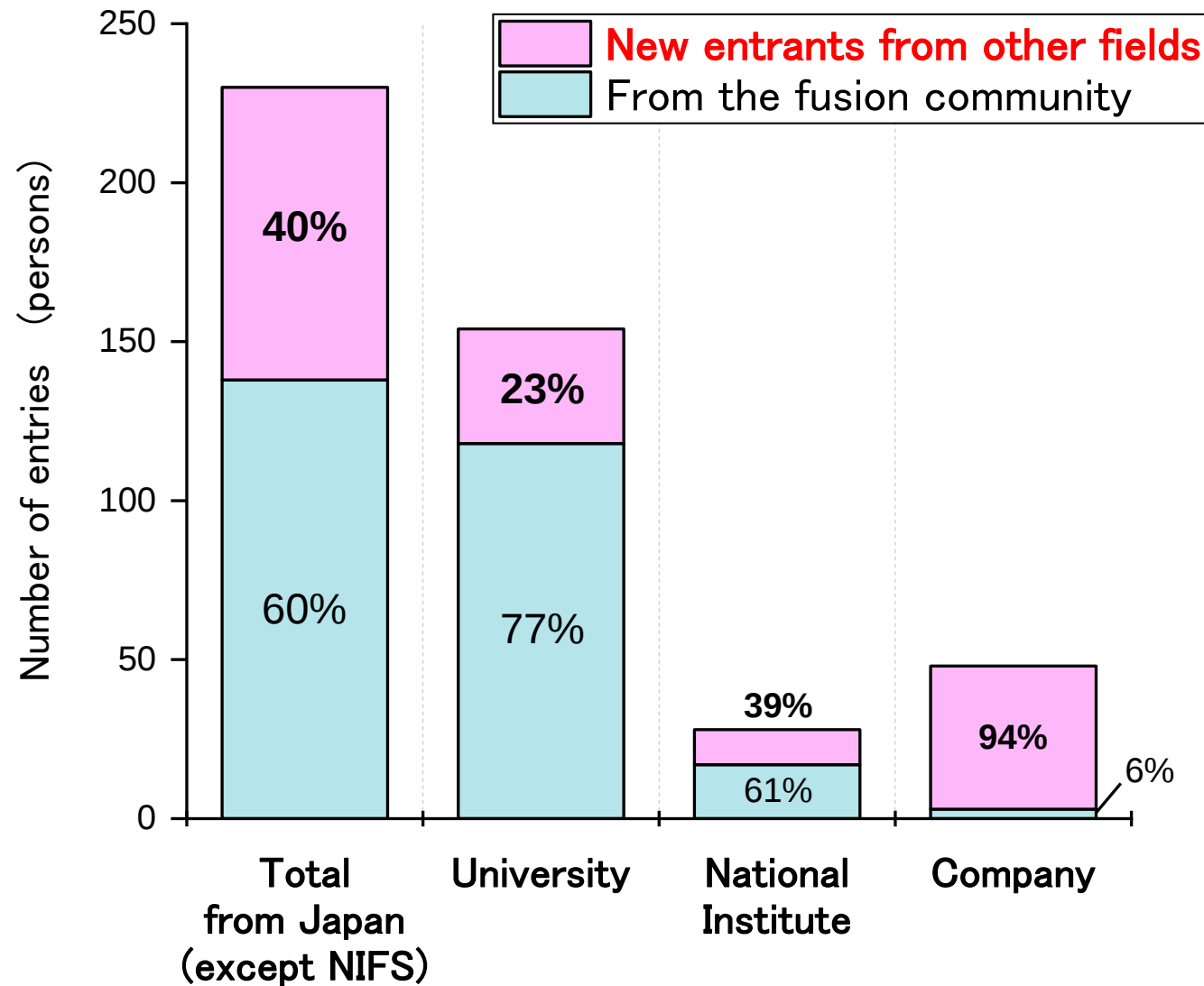
National Institute



Company

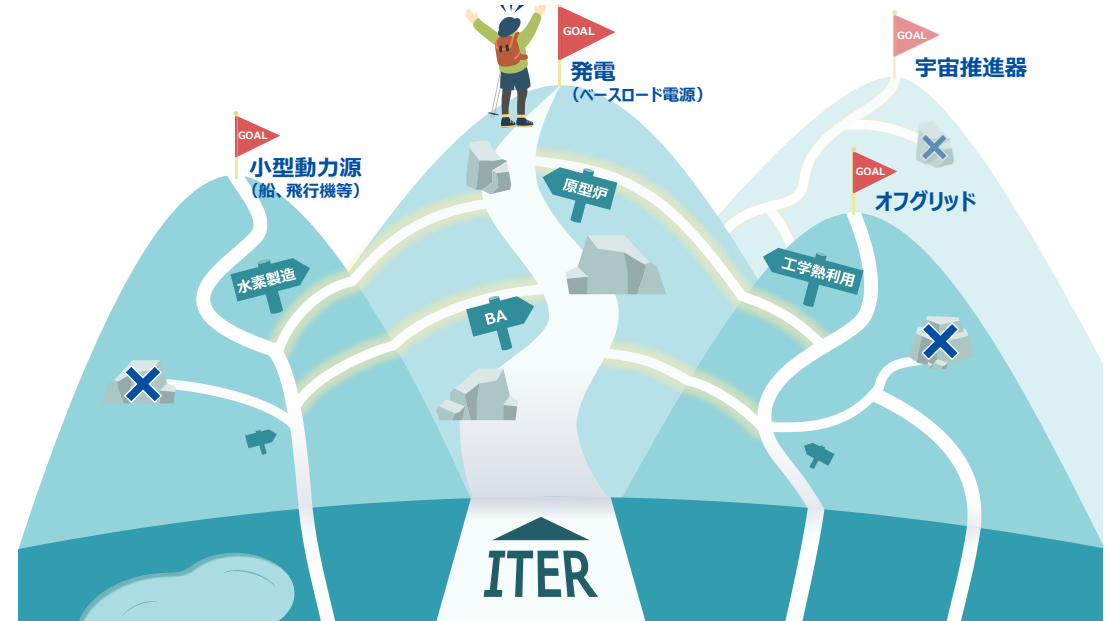


IIS2024 Percentage of new entrants in Japan

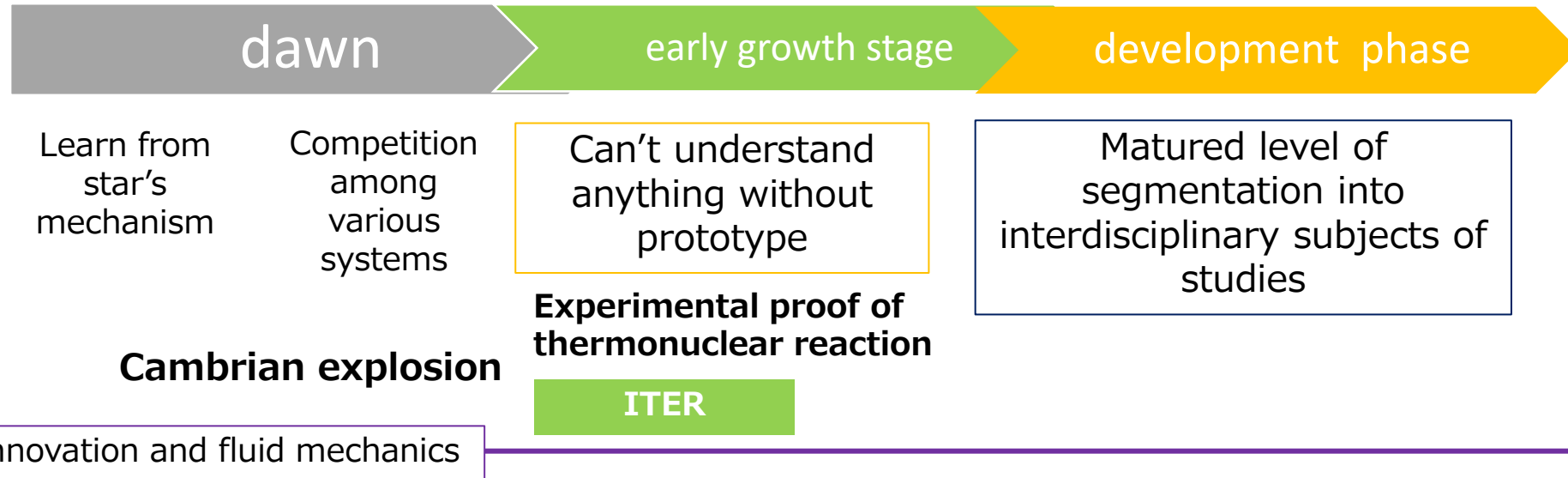


Paradigm-shift for inclusive strategy

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



Paradigm-shift for the evolution of fusion study



Learn from nature



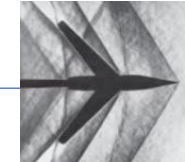
Various ideas



Wright Flyer



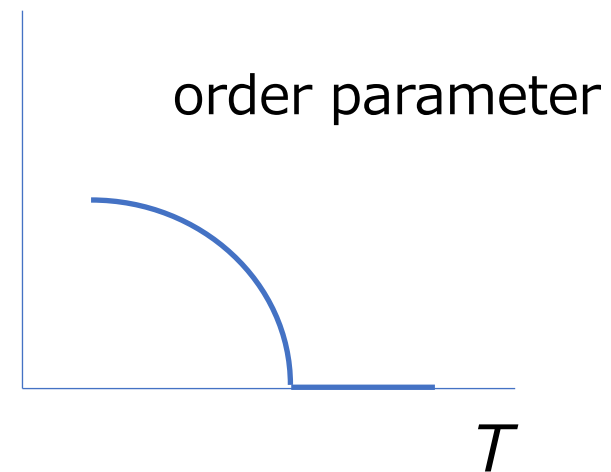
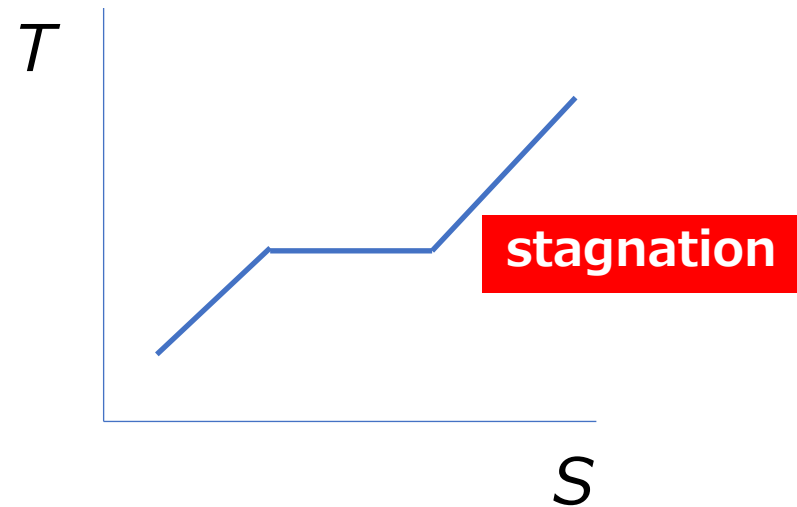
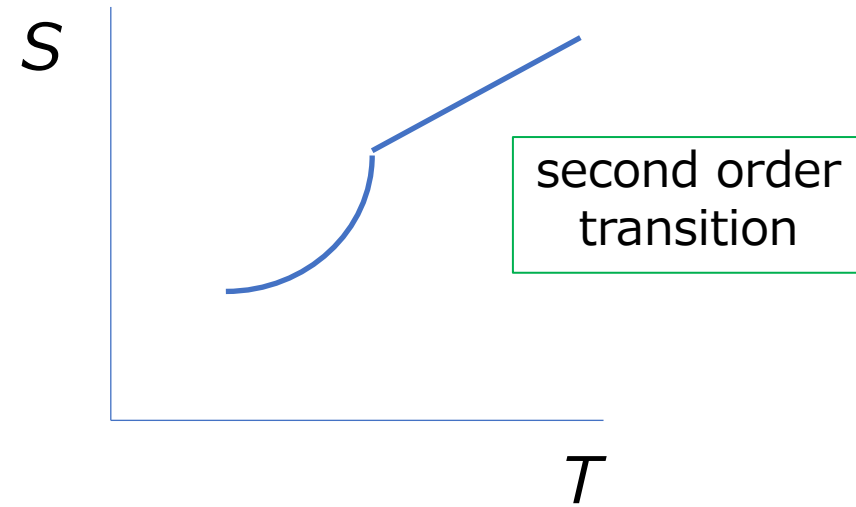
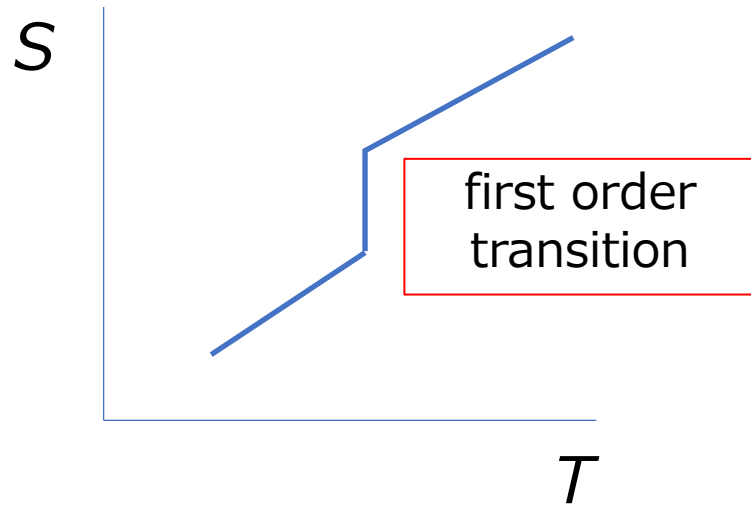
Collaboration between science and technology



Basic science drives innovation

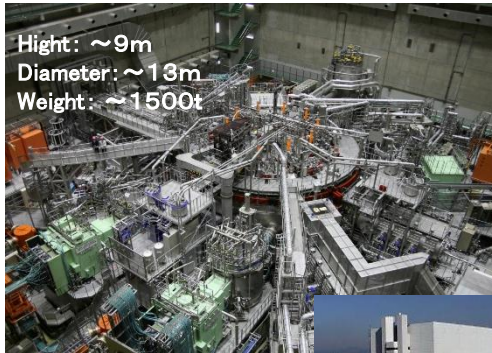


Q: How can we make the phase transition *second order* ?



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

Large Helical Device (LHD)



Height: ~9m
Diameter: ~13m
Weight: ~1500t

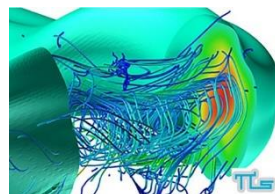
- One of the world's largest superconducting plasma experimental devices
- Various physics research utilizing steady, high-precision magnetic fields
- World's most accurate measurement devices to elucidate the internal structure of plasma → Experimental research on all phenomena in the universe



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

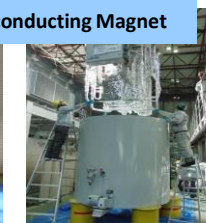


Core Testing Facilities for Fusion Engineering



Superconducting Magnet

13 T, ϕ 700 mm
Solenoid Coil



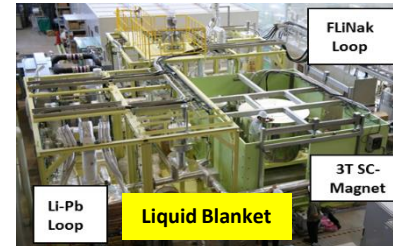
Temperature Variable
Helium Refrigerator



High-Temp, High-Vacuum
Creep Test Facilities



Advanced
Materials



FLiNaK
Loop

3T SC-
Magnet

Li-Pb
Loop

Liquid Blanket

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



High Heat Flux
Component

Tandem Accelerator for
Ion Beam Surface Analysis

High Heat Flux Testing
Facility (ACT2)

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