

# WHAT'S NEW IN FUSION

DR. FRED BERANEK

DIRECTOR OF ENGINEERING, FLUOR NUCLEAR POWER

OCTOBER 22, 2025

# SESSION 1

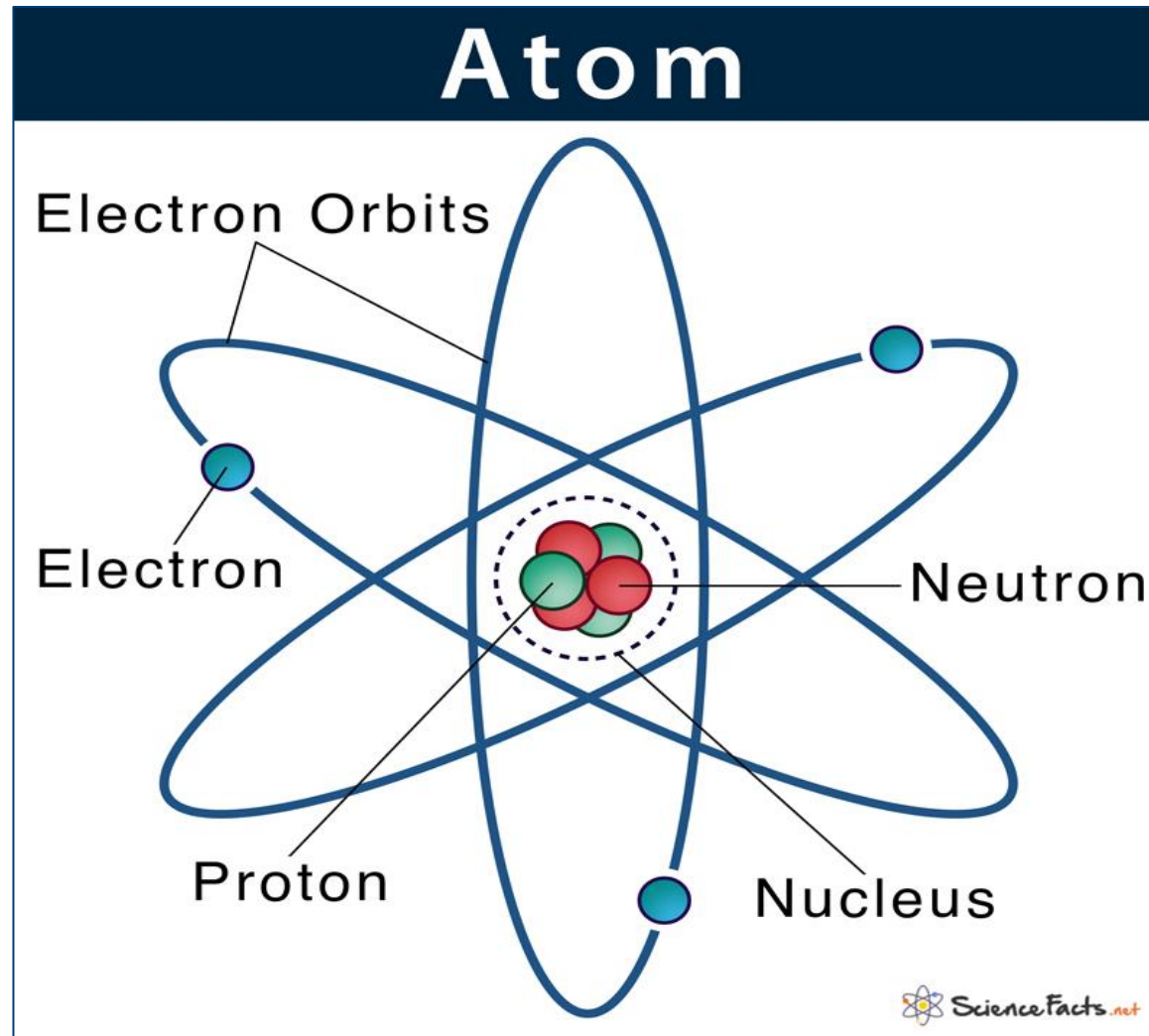
## Fusion Basics and Magnetic Fusion Concepts

- ▶ 50% of fusion companies are pursuing magnetic fusion engines
- ▶ 50% of these companies are using tokamaks or stellarators
- ▶ World-wide research activities are predominantly magnetic

# SESSION 2

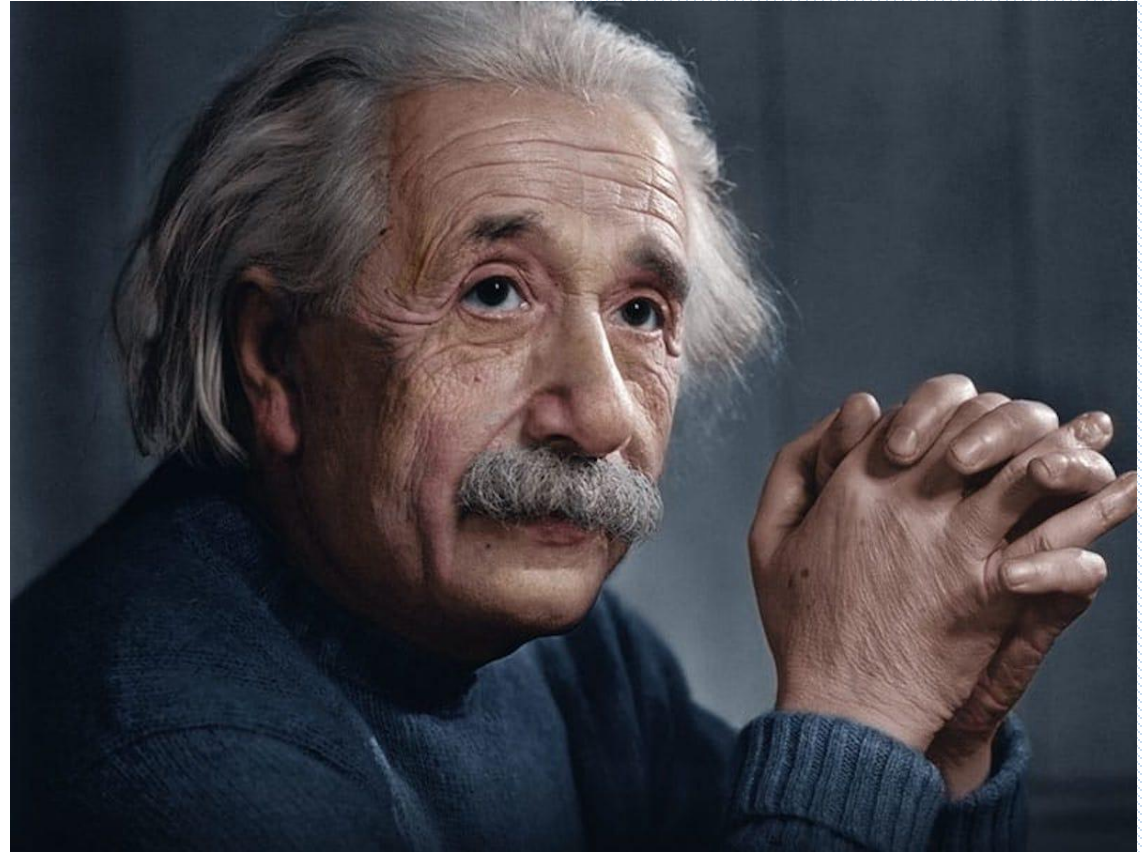
## Inertial Confinement Fusion Concepts

- ▶ 25% of fusion companies are pursuing inertial confinement fusion engines
- ▶ 50% of these companies are using lasers for inertial confinement
- ▶ Research is difficult due to laser power required
- ▶ Still the only technique which has demonstrated net energy from fusion



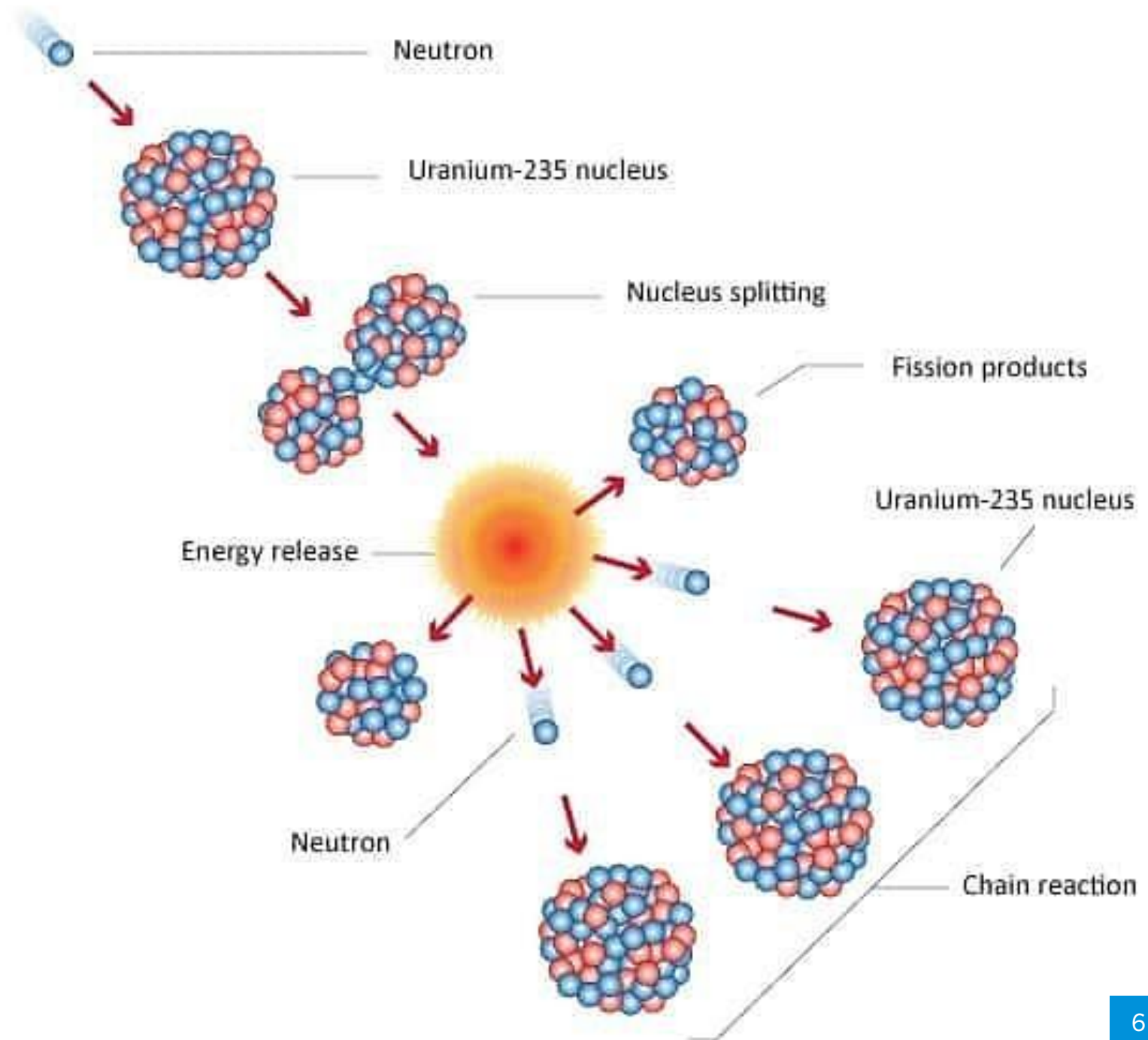
[Atom: Definition, Structure & Parts with Labeled Diagram](https://www.sciencefacts.net/atom-definition-structure-parts/)  
([sciencefacts.net](https://www.sciencefacts.net/))

$$E = mc^2$$

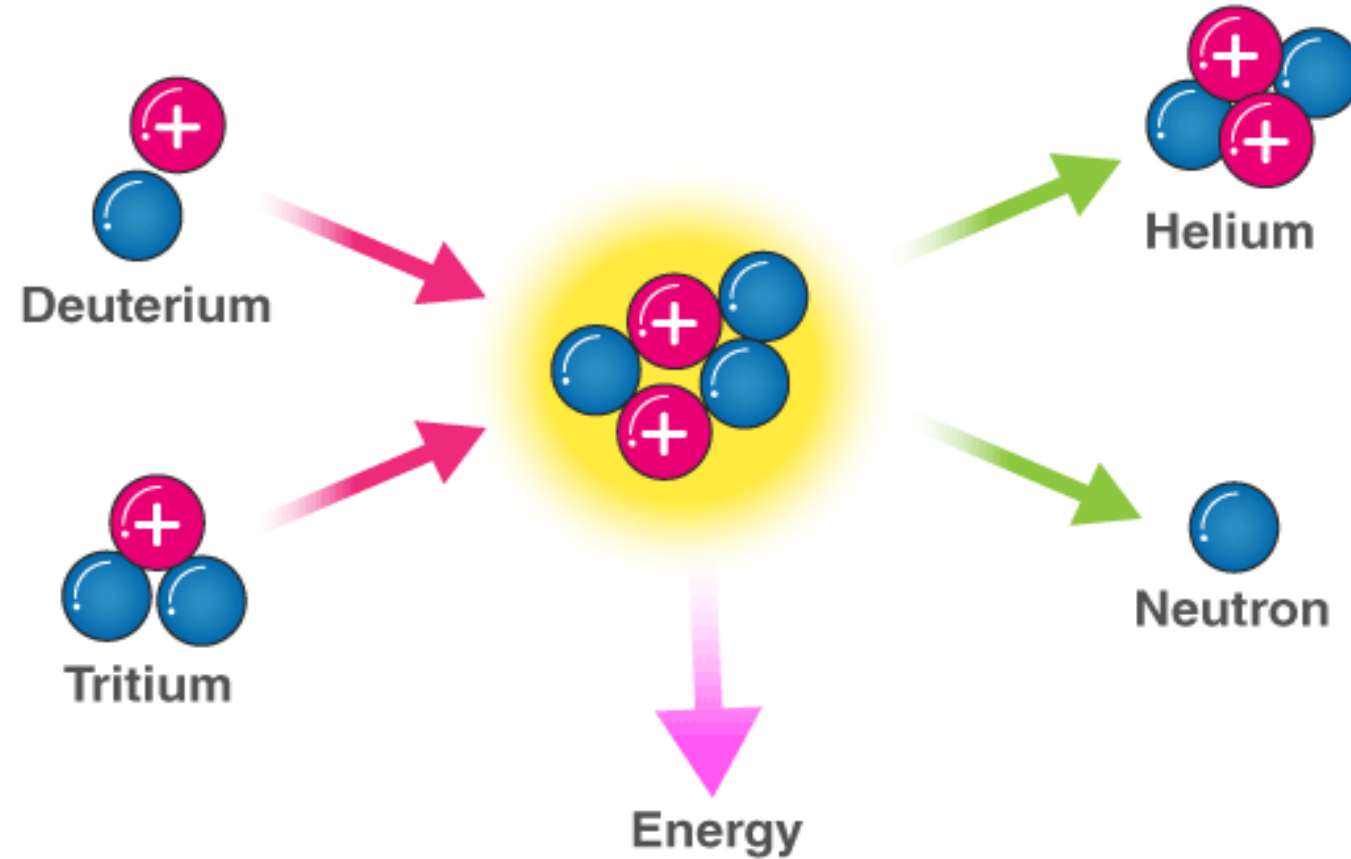


[Albert Einstein: His Early Life, Discoveries, and Theories - Malevus](#)

# Nuclear Fission



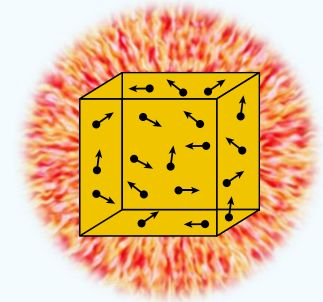
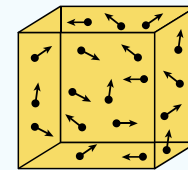
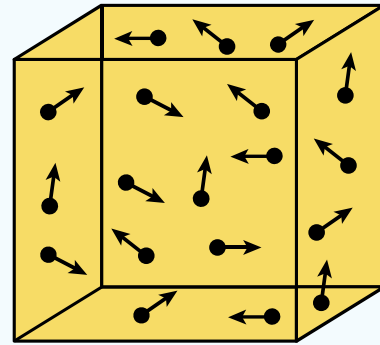
# NUCLEAR FUSION



[Nuclear Fusion - Definition, Occurrence, Examples, Applications & FAQs \(byjus.com\)](#)

# MECHANICS OF FUSION

- ▶ Density
- ▶ Temperature/Energy
- ▶ Time
- ▶ Triple Product



Density

Temperature/Energy  
>100,000,000 C

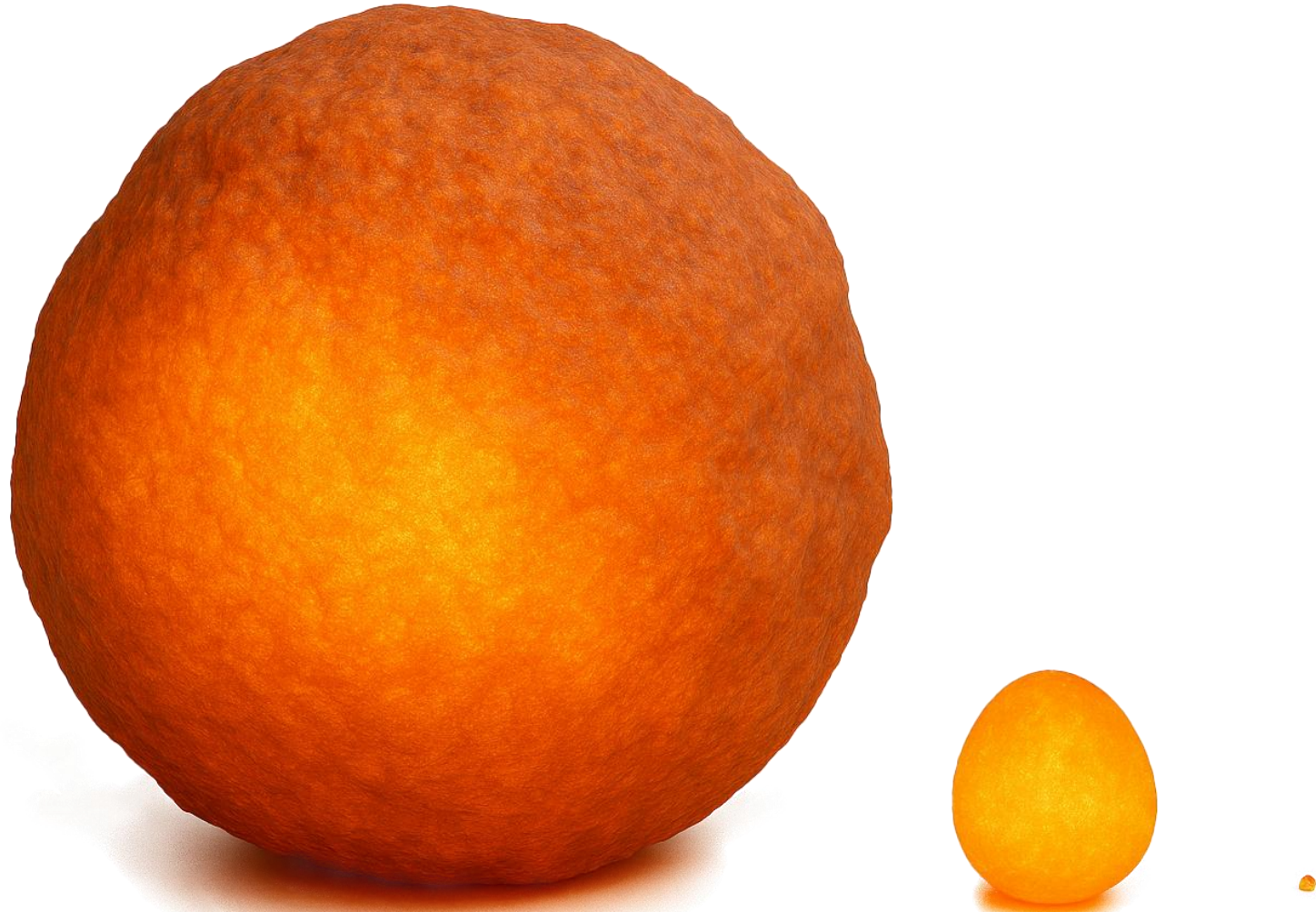


# NET ENERGY



# 100,000,000 C IS HOT!

Any material in contact with the hydrogen at that temperature would vaporize





# COMPRESSING HYDROGEN



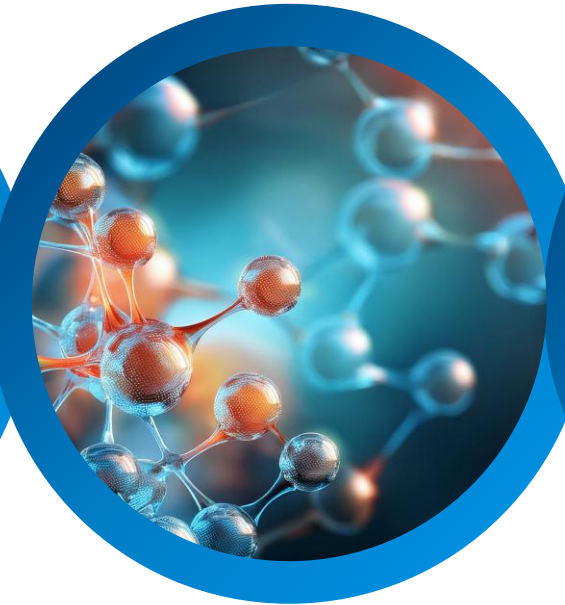
# ADVANTAGES OF FUSION ENERGY



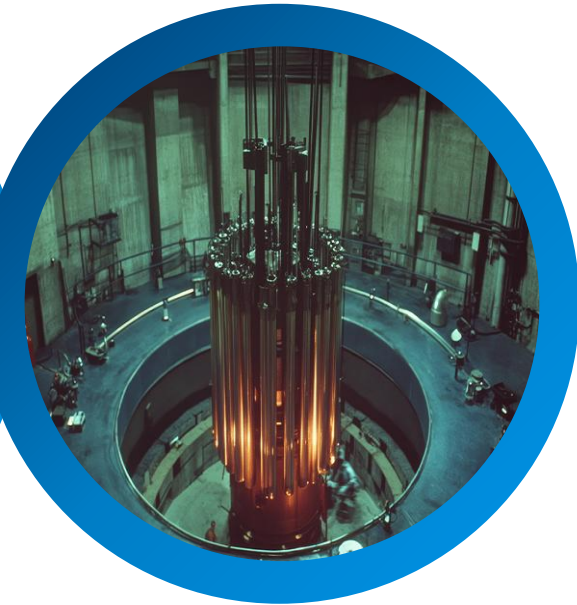
**Abundant  
fuel source**



**No  
High-level Waste**

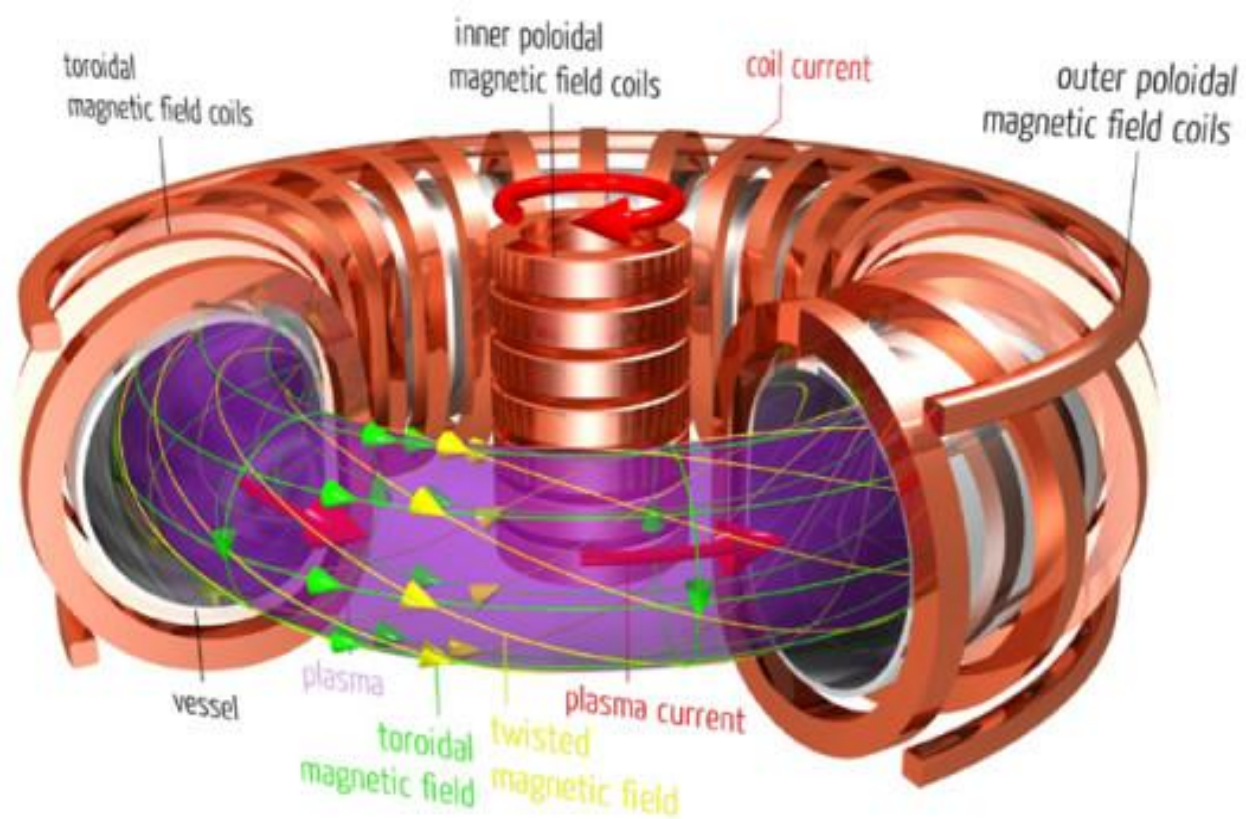


**No  
Runaway Reactions**



**No  
Long-term Cooling**

# GENERIC TOKAMAK

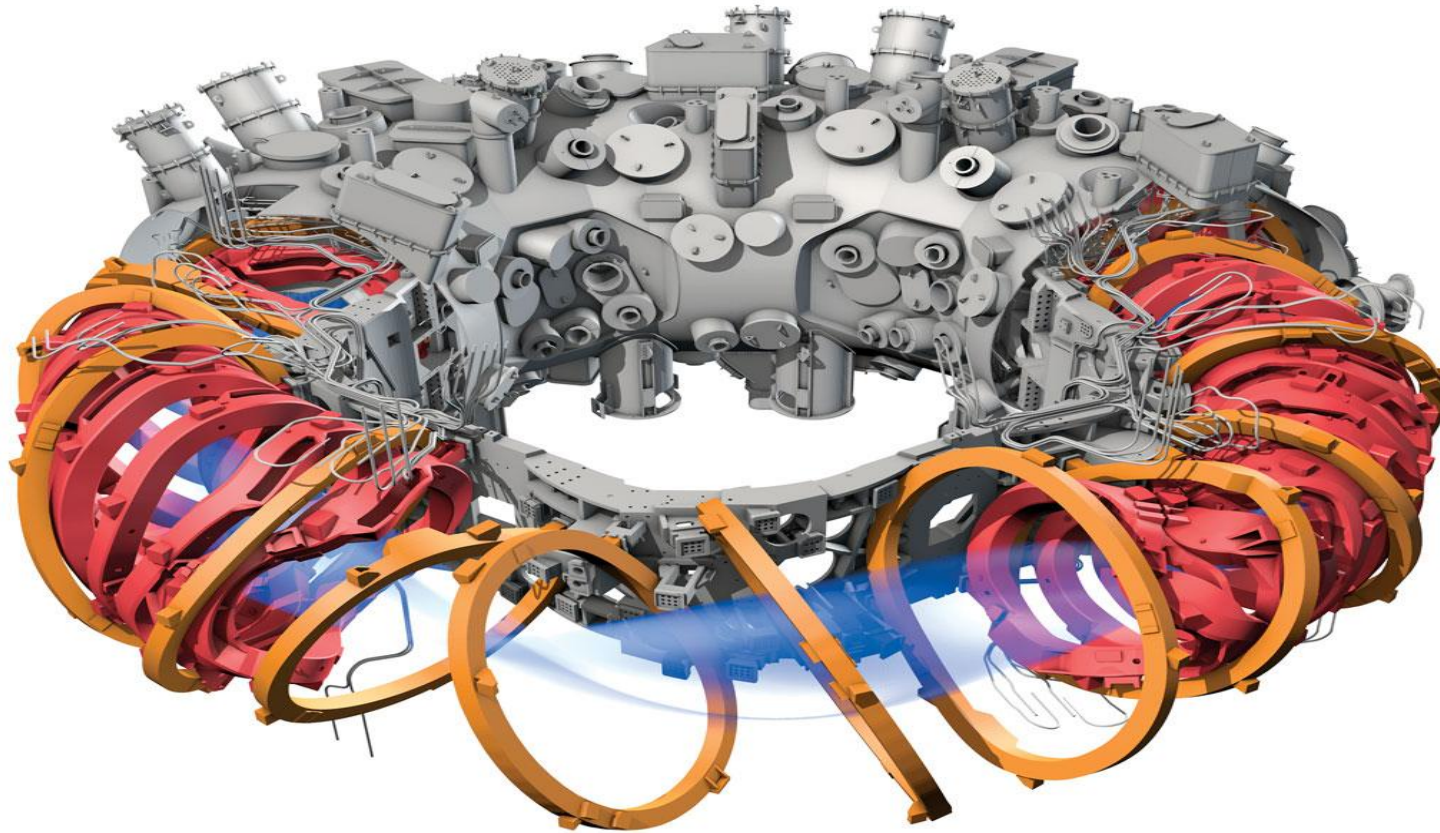


[https://www.engineering.com/wp-content/uploads/2024/08/Tokamak\\_\\_scheme\\_w2djec.jpg](https://www.engineering.com/wp-content/uploads/2024/08/Tokamak__scheme_w2djec.jpg)



# WENDELSTEIN 7-X STELLARATOR

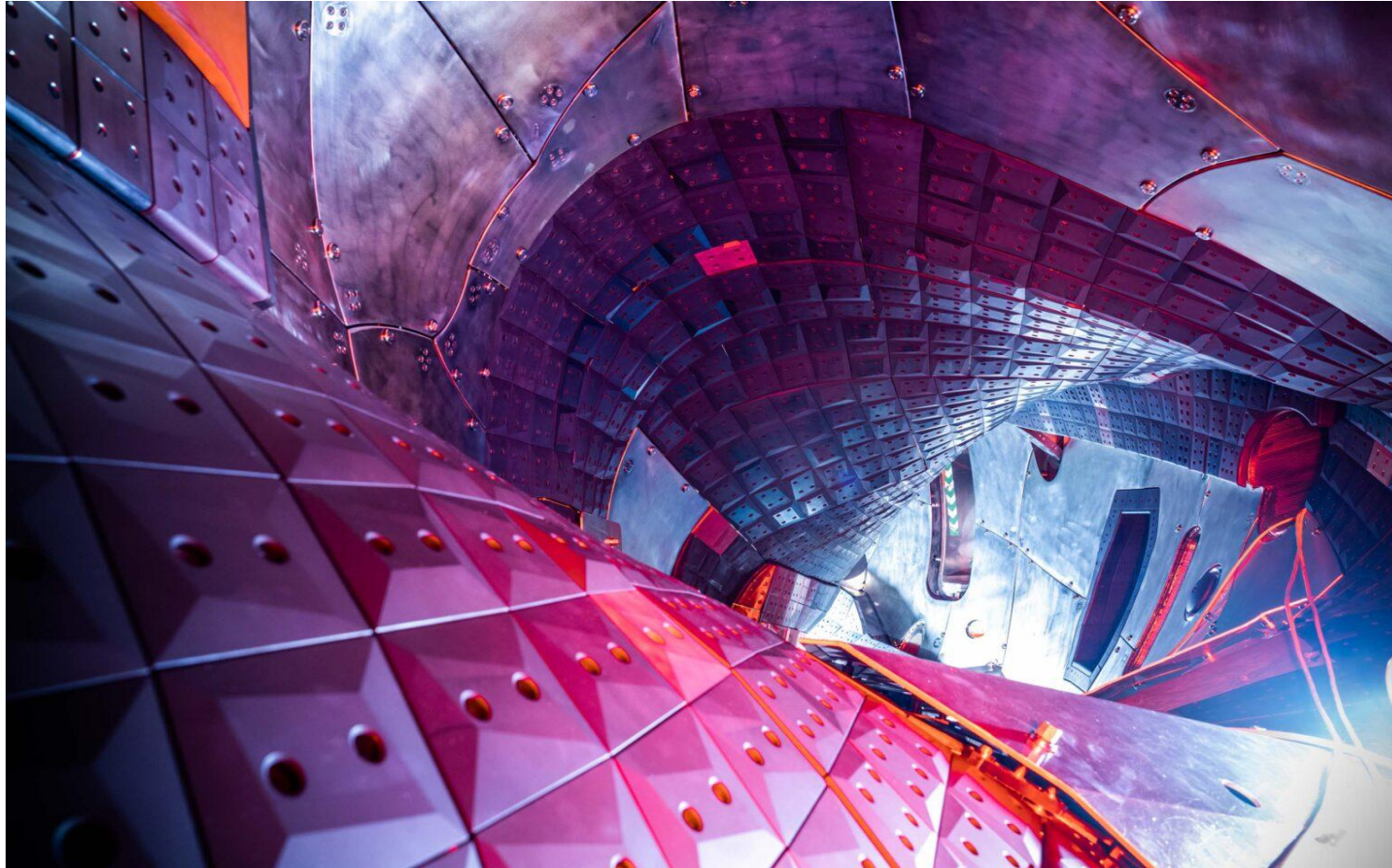
**FLUOR**<sup>®</sup>



[https://www.science.org/doi/10.1126/science.ade7849/full/\\_20220715\\_nid\\_stellarator\\_lead-1675042999003.jpg](https://www.science.org/doi/10.1126/science.ade7849/full/_20220715_nid_stellarator_lead-1675042999003.jpg)

# W7-X STELLERATOR

## Inside the Machine

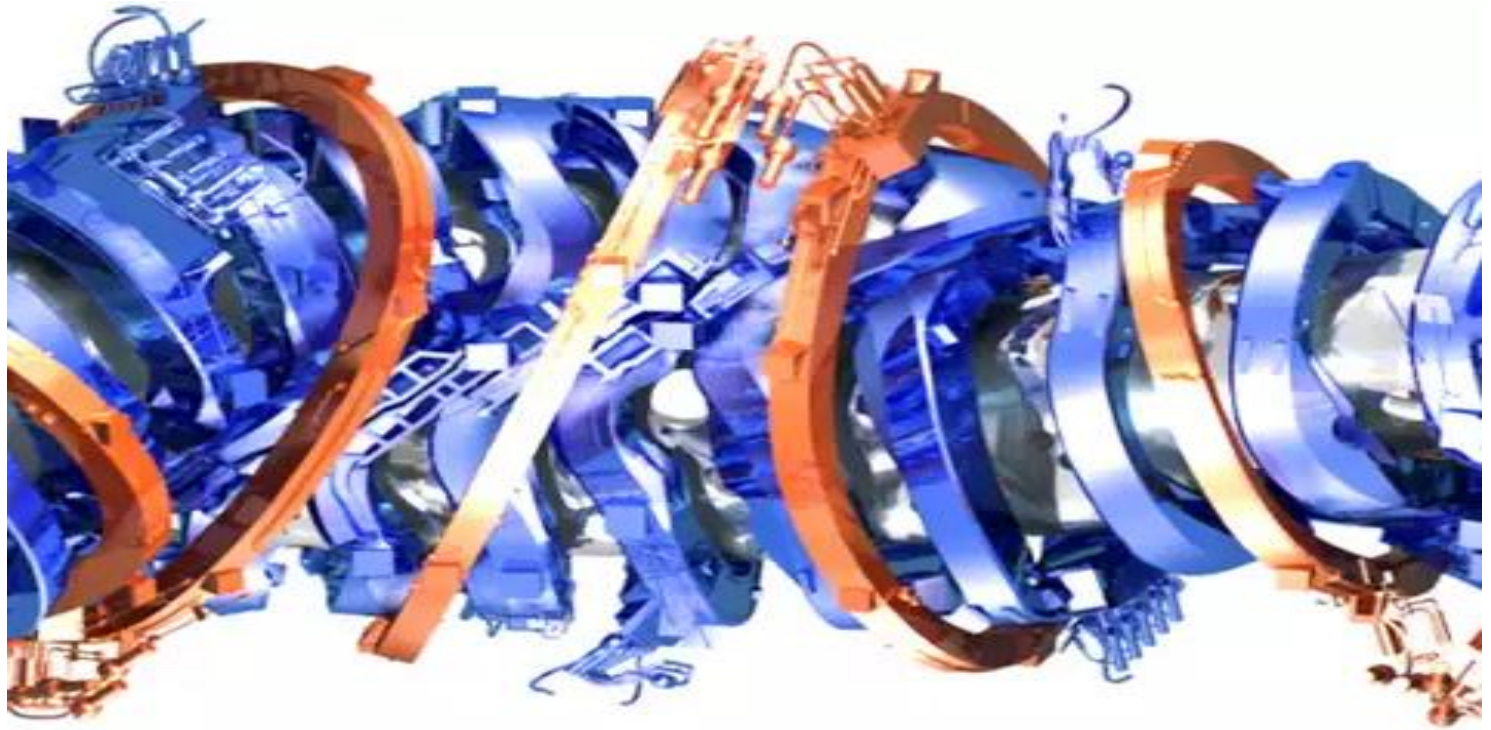


[https://euro-fusion.org/wp-content/uploads/2025/06/Plasmagefas\\_Wendelstein7-X\\_Hosan\\_Nov\\_21\\_2-1536x1025.jpg](https://euro-fusion.org/wp-content/uploads/2025/06/Plasmagefas_Wendelstein7-X_Hosan_Nov_21_2-1536x1025.jpg) - used for educational purposes



# WORLD RECORD TRIPLE PRODUCT FOR LONG DURATIONS

- Wendelstein 7-X stellarator
- May of 2025
- 43 seconds
- 20 million degrees

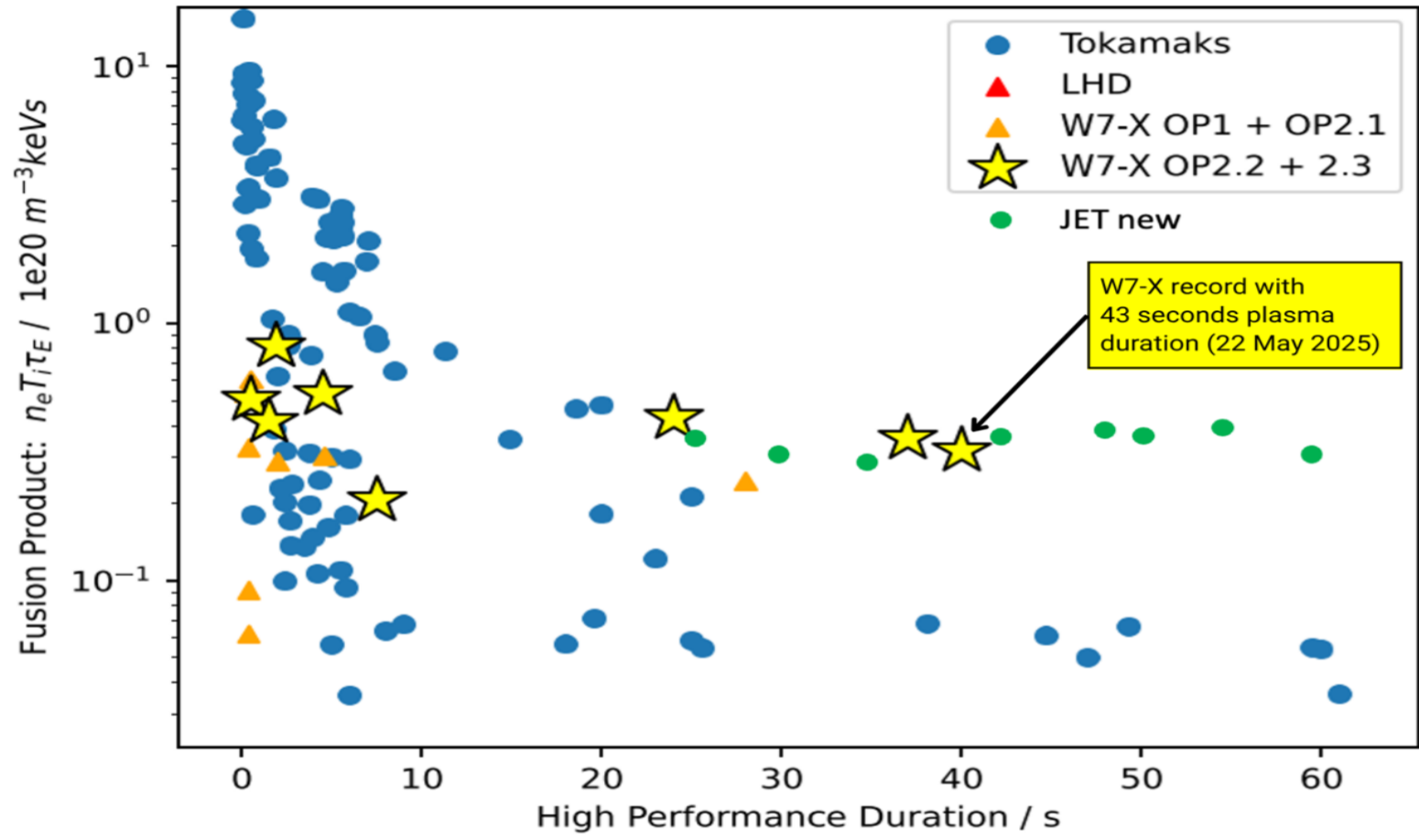


[https://www.ipp.mpg.de/262918/header\\_image-1744285711.webp?t=eyJ3aWR0aCI6MTY5NiwiZmlsZV9leHRlbnNpb24iOiJ3ZWJwliwib2JqX2lkIjoyNjI5MTh9--aa953e66ad1a98778bbdf321efd05152a67c73e5](https://www.ipp.mpg.de/262918/header_image-1744285711.webp?t=eyJ3aWR0aCI6MTY5NiwiZmlsZV9leHRlbnNpb24iOiJ3ZWJwliwib2JqX2lkIjoyNjI5MTh9--aa953e66ad1a98778bbdf321efd05152a67c73e5)



# WORLD RECORD TRIPLE PRODUCT

## W7-X Stellerator



[https://euro-fusion.org/wp-content/uploads/2025/07/EN\\_2.png](https://euro-fusion.org/wp-content/uploads/2025/07/EN_2.png) - used for educational purposes

# MAGNETIC FUSION ACHIEVEMENTS

- ▶ Joint European Torus (JET) facilities
- ▶ Deuterium-tritium plasma
- ▶ 150 M degrees C
- ▶ Five seconds



# MAGNETIC FUSION ACHIEVEMENTS (continued)

- ▶ HL-3 Machine in China
- ▶ Deuterium-tritium plasma
- ▶ 160 M degrees C
- ▶ Fusion triple product “rose significantly”



[https://www.iter.org/sites/default/files/styles/responsive\\_1100w/public/media/2025-03/swipexperiment1\\_sm.jpg.webp?itok=iHQwPE8g](https://www.iter.org/sites/default/files/styles/responsive_1100w/public/media/2025-03/swipexperiment1_sm.jpg.webp?itok=iHQwPE8g)



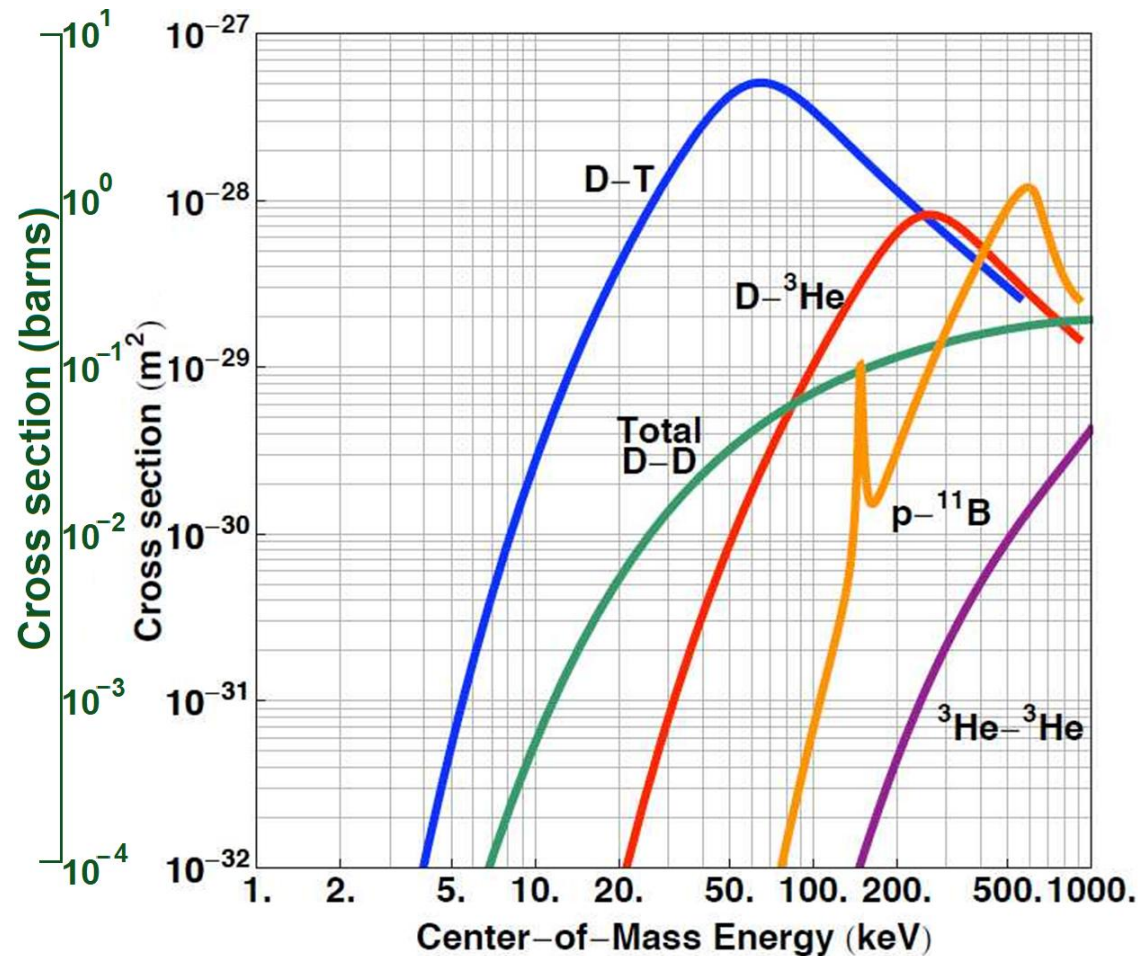
# MAGNETIC FUSION ACHIEVEMENTS (continued)

- ▶ WEST tokamak in France
- ▶ Deuterium-tritium plasma
- ▶ 50 M degrees C
- ▶ Maintained for 1,337 seconds
  - Beat previous record set weeks earlier in the EAST tokamak by 25%



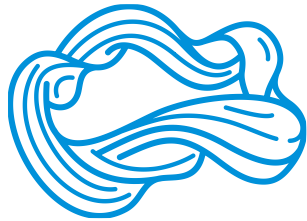


# FUSION FUEL OPTIONS



- ▶ **Blue curve: Deuterium/tritium**
  - Highest reaction rate at “lower” temperatures
  - Emits very high energy neutrons
- ▶ **Red curve: Deuterium/Helium-3**
  - Product is helium and hydrogen
  - Few neutrons produced
- ▶ **Yellow curve: Proton/Boron-11**
  - Product is helium with no neutrons
  - Holy grail of fusion

# CHALLENGES TO COMMERCIAL FUSION



**Plasma Instabilities**



**Materials**



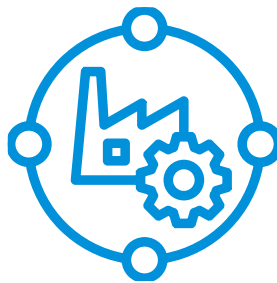
**Tritium Extraction  
and Recycle**



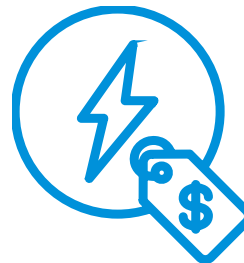
**Pellet Design & Fabrication  
(Inertial Fusion)**



**Laser Design  
(Inertial Fusion)**



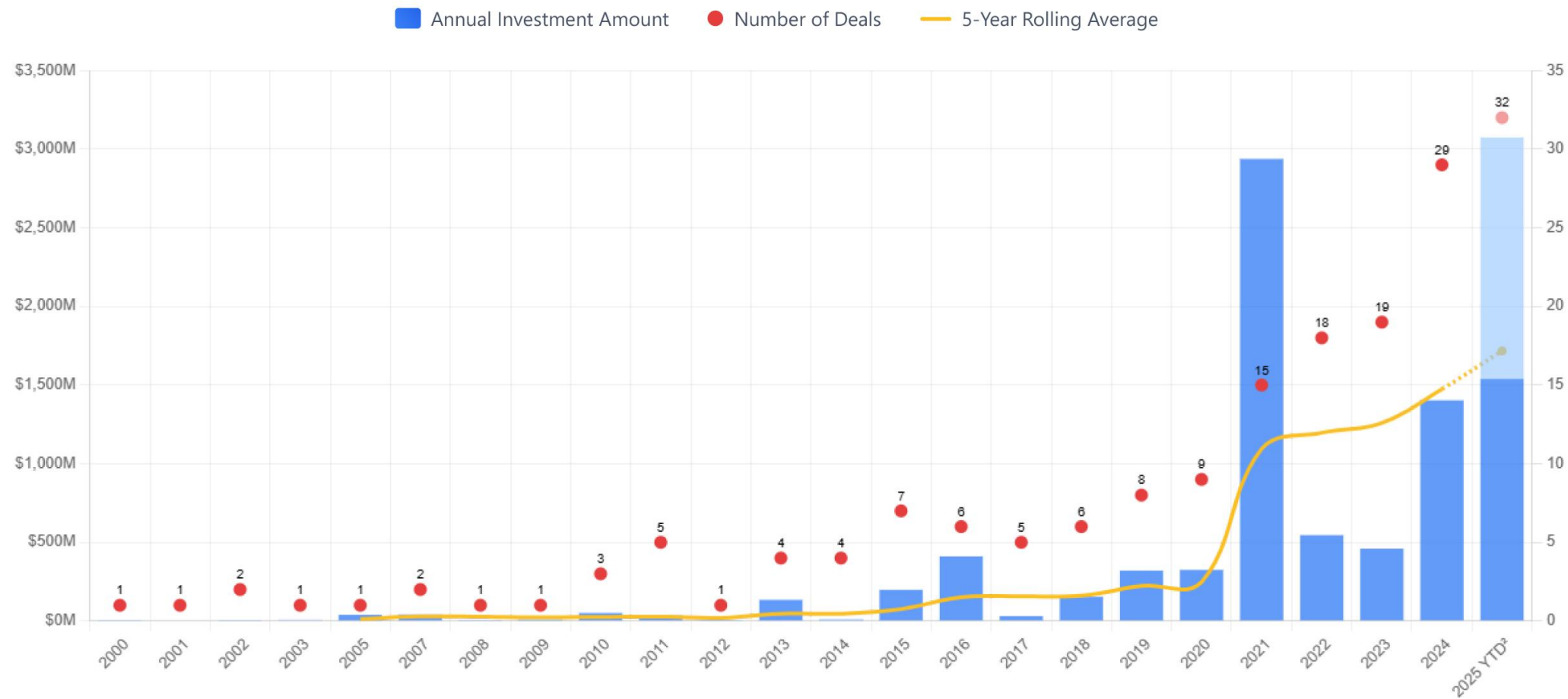
**Supply Chain**



**Cost of Electricity**

# INVESTMENT IN FUSION INDUSTRY

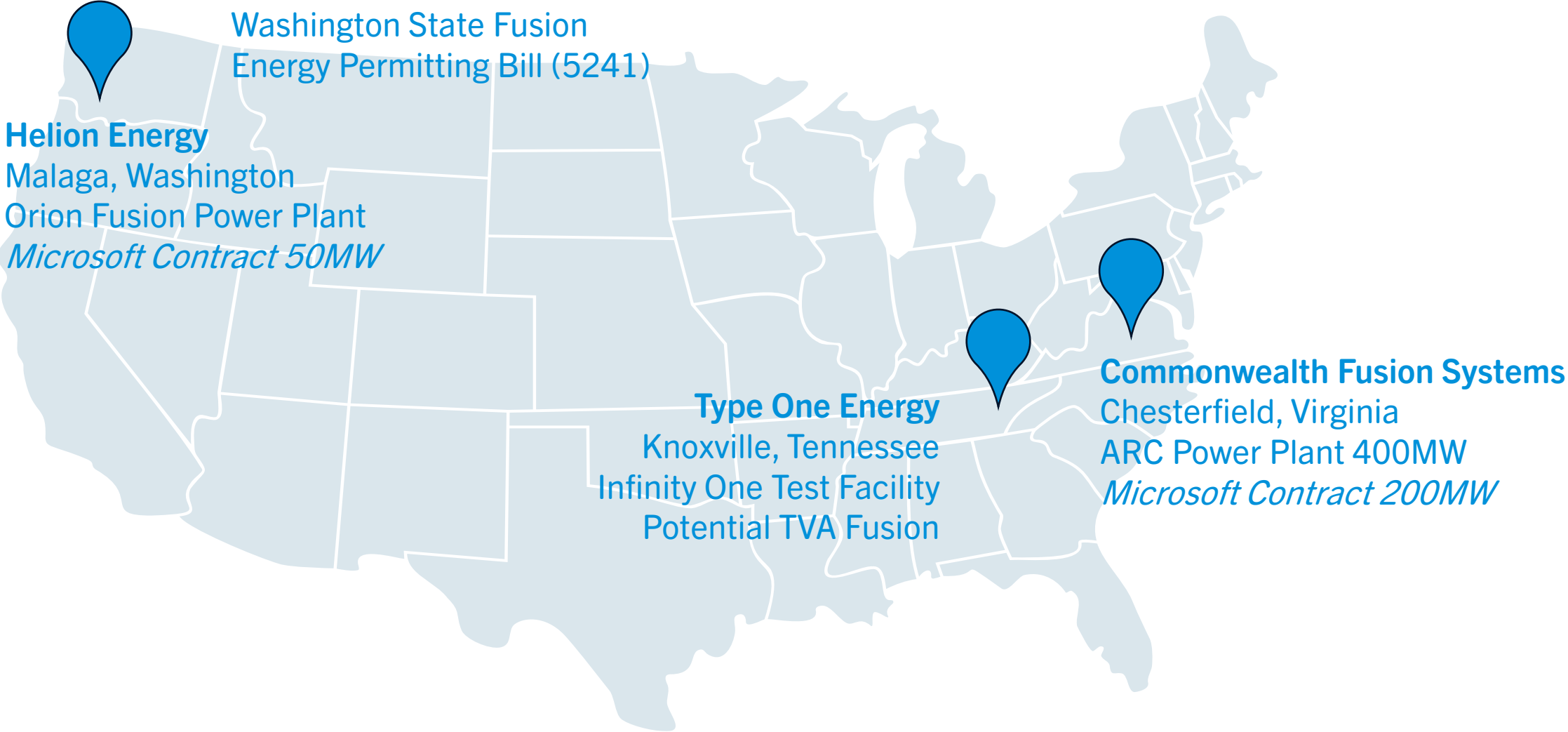
Equity Investment Received, Private Sector Fusion<sup>1</sup>



Notes: 1. Private sector fusion, excludes all China; 2. 2025 YTD w. annualised total and no. of deals

Source: FusionX

# WHAT'S NEW IN THE FUSION INDUSTRY?





# WHAT'S NEW IN THE FUSION INDUSTRY?

- ▶ Washington State Governor signed a bill to streamline permitting for fusion energy projects
- ▶ Microsoft has contract with **Helion** for 50 MW by 2028
- ▶ Google signs power purchase agreement with **Commonwealth** for 200MW
- ▶ Eni agreed to purchase \$1B of fusion power from Commonwealth
- ▶ Germany committed 2B Euros for fusion research
- ▶ Pacific Fusion to construct its Demonstration System in Albuquerque, NM with a \$1B investment