# Testing cutting-edge AI research to increase pattern recognition and image classification in nuclear fusion databases

Presented by  A. Pereira

augusto.pereira@ciemat.es

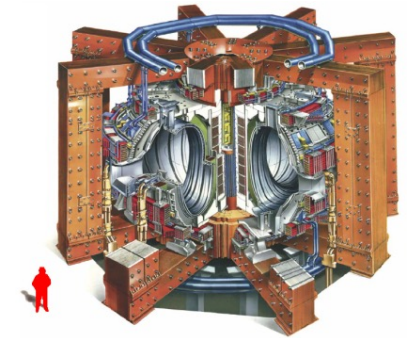KoM AI&ML EUROfusion projects / 21 May 2024

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Infraestructuras Científicas y Técnicas Singulares

EUROfusion

# Index

Laboratorio Nacional de Fusión
Ciemat

## Facilities

Processed data < 10%
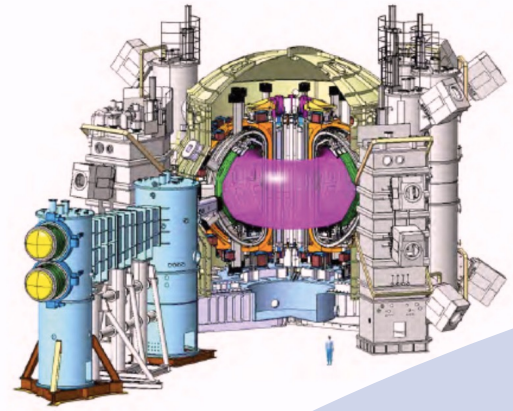
Tens of Pb ?
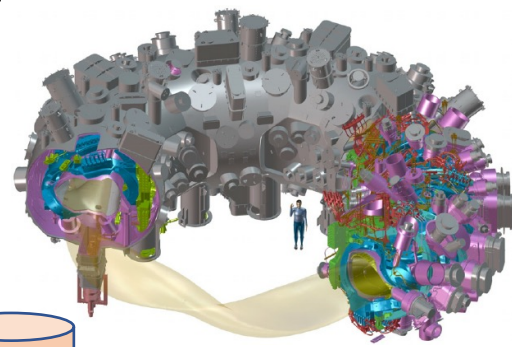
1Tb/discharge
100 Pb/year

**ITER**

**JT60-SA**

**W7-X**

**JET**

300 Tb / 40 years
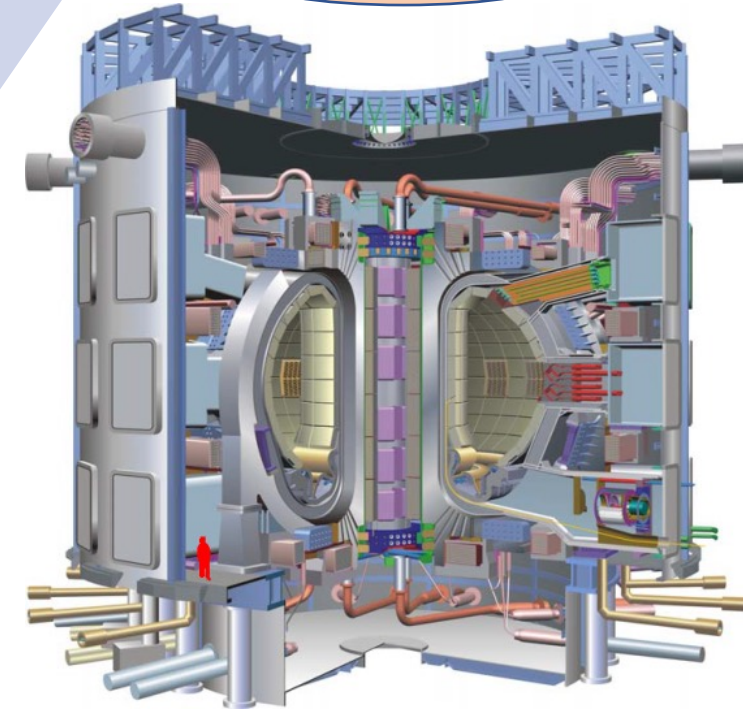
Much more data will be generated, and it will remain unanalyzed

**TJ-II**

Hundreds of Tb / year ?

18 Tb / 23 years

**Need to interpret and process massive data to extract relevant knowledge**

## W7-X

## Interested and focused on detecting novel recognition patterns:
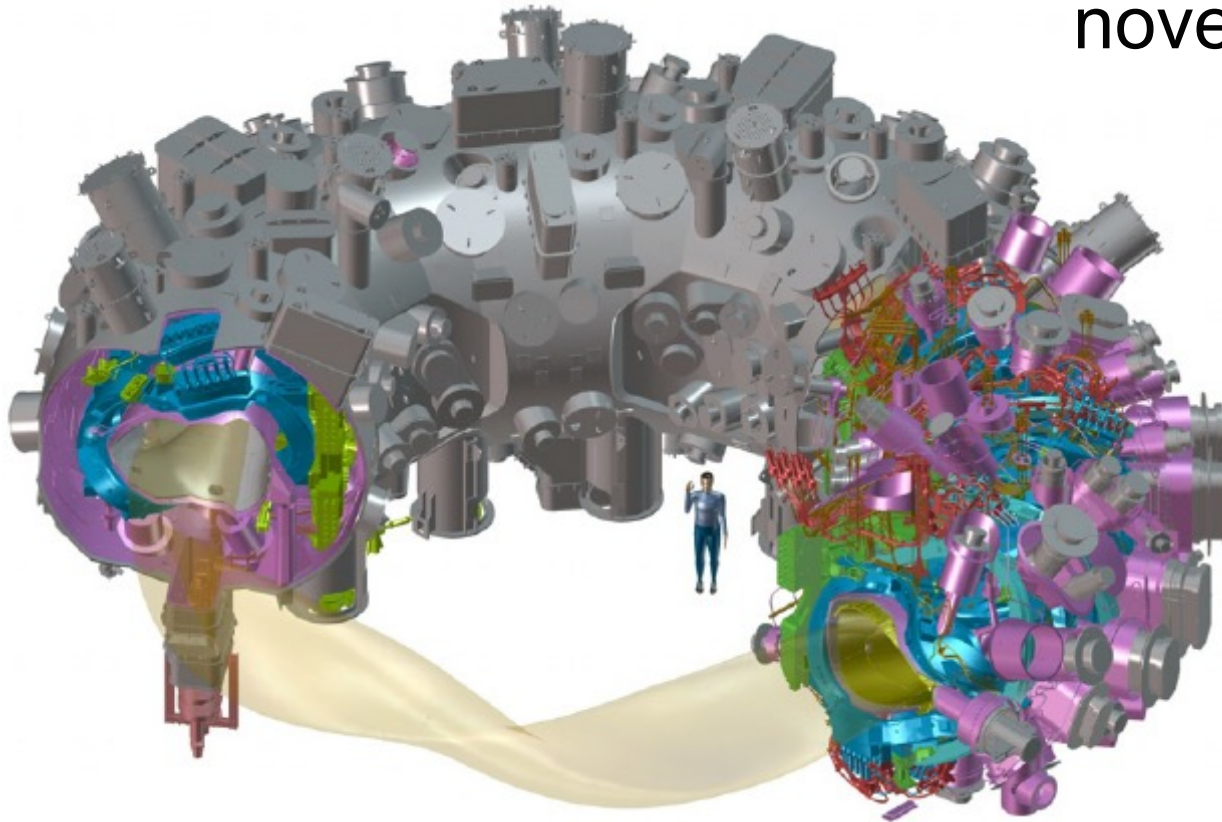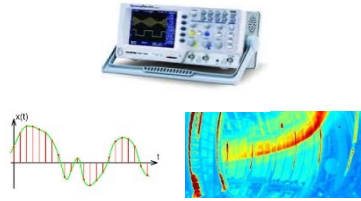
### Generative AI Cloud - Video Indexer
- Extracting AI-based meaning from IR and video data

### AI Bot Services
- Create conversational AI experiences and semantic LLM approaches for users

# Background

Nuclear fusion devices
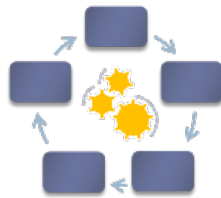
Learning in huge data-bases
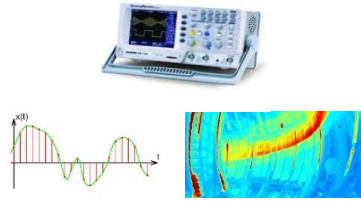
Signals, images and meta-data

Supercomputing

Investigate, explore, identify, search, detect, improve, predict, classify, forecast, analyze, calculate, evaluate, adjust, group, understand, visualize, recommend, control, optimize,... SOLVE

Automate learning tasks

Create technological tools that implement intelligent functions

# Objectives


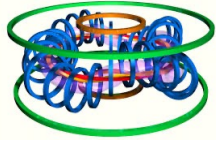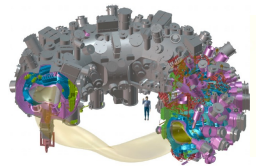
Nuclear fusion devices

Learning in huge data-bases

**Adding generative AI cloud models**

Signals, images and meta-data

Supercomputing

(New resource)

**To combine searches on semantic and scientific data to take advantage of conversational approaches and to extract relevant knowledge**

Automate learning tasks

Create technological tools that implement intelligent functions

(New service)

# Specific goals
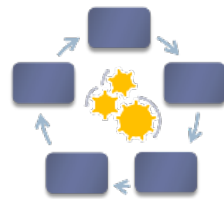
## General tasks for all EUROFUSION AI projects

- Explore the potential of innovative AI/ML methods aimed at advancing research and development in the field of fusion energy

- AI-driven optimization of fusion machine operation

- Proof of concept for the use of AI/ML methods in support to operation (Chat GPT like) by contributing to decisions in control room

- Exploitation of the EUROfusion multi-machine databases using new AI methods

# Specific goals

## Specific tasks within the project

- Conduct a <span style="color:red">study</span> of generative AI cloud solution

- Develop and implement a <span style="color:red">real</span> generative AI cloud model

- <span style="color:red">Exploring the possibility to prepare</span> the <span style="color:red">W7-X and TJ-II databases</span> with the requirements imposed by the implemented model

- <span style="color:red">Test</span> the implemented services to generate pattern recognition in signals/images and to check other classification tasks

# Expected outcomes
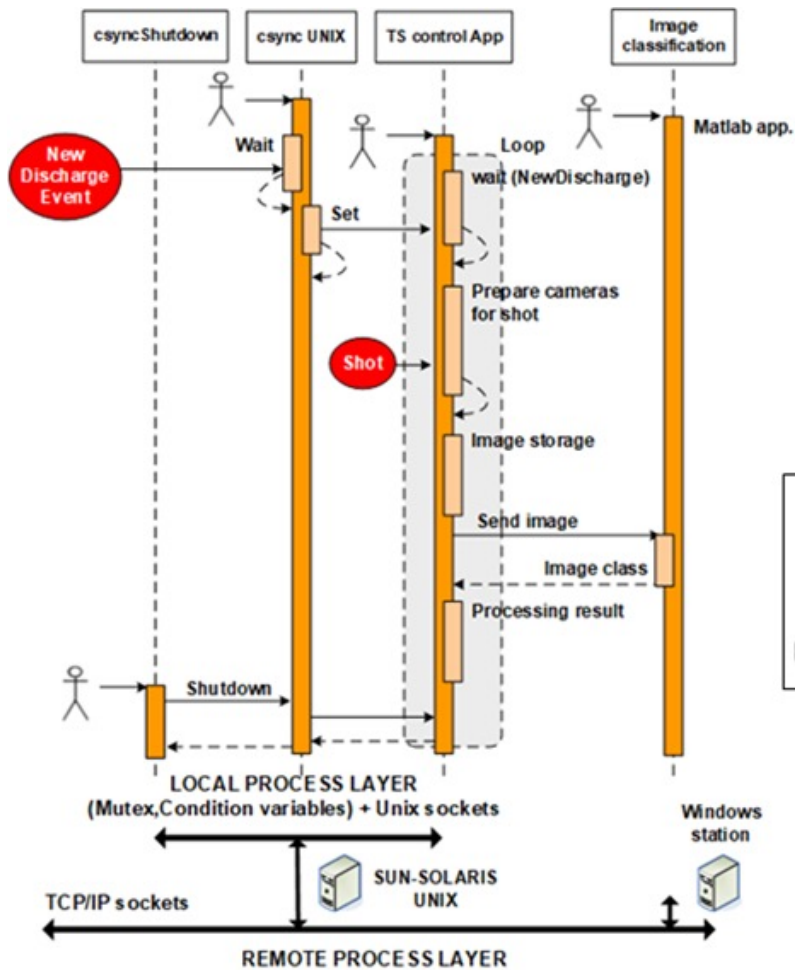
UML sequence diagram

**Upgrade for adding new prediction capabilities**
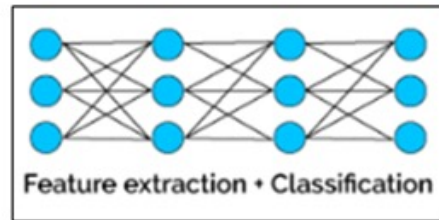
Modular predictor:

- Deep learning techniques

Feature extraction + Classification

**Magnetic fluctuation spectrograms**
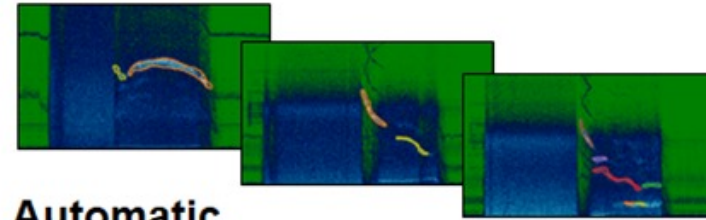
✓ Automatic identification of MHD modes

Different patterns of time-frequency

LLM

✓ **Generative-AI cloud model**

AI chat playground
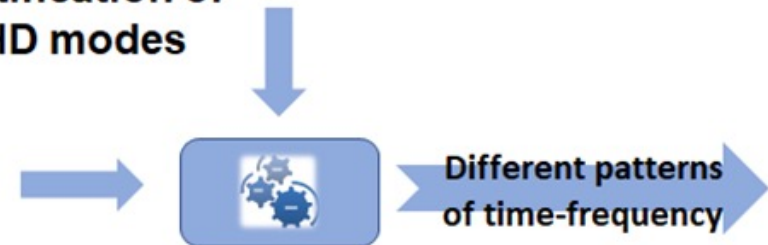
# Milestones and schedule

| Activity | Activity description | 2024 | | | |
|---|---|---|---|---|---|
| | | January-March | April-June | July-September | October-December |
| 1 | Conduct a study of the generative AI cloud solutions currently offered by the large technology market | | ▓ | ▓ | ▓ |
| 2 | Develop and implement a real generative AI cloud model based on the previous selection | | | | |
| 3 | Prepare the TJ-II applications and databases with the requirements imposed by the implemented model | | | | |
| 4 | Test the implemented services to generate pattern recognition in signals and to verify image classification using the TJ-II database | | | | |
| 5 | Migrate a similar proof of concept to the W7X stellarator | | | | |

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- This project will not finish in 2 years, regardless of the results achieved, generative AI cloud models are here to stay from now on

- This proof of concept will allow the promotion of international AI strategies in a cooperative manner and will foster an ecosystem of AI creators and builders with the aim of being able to access future exploitation contracts

Thank you for your attention