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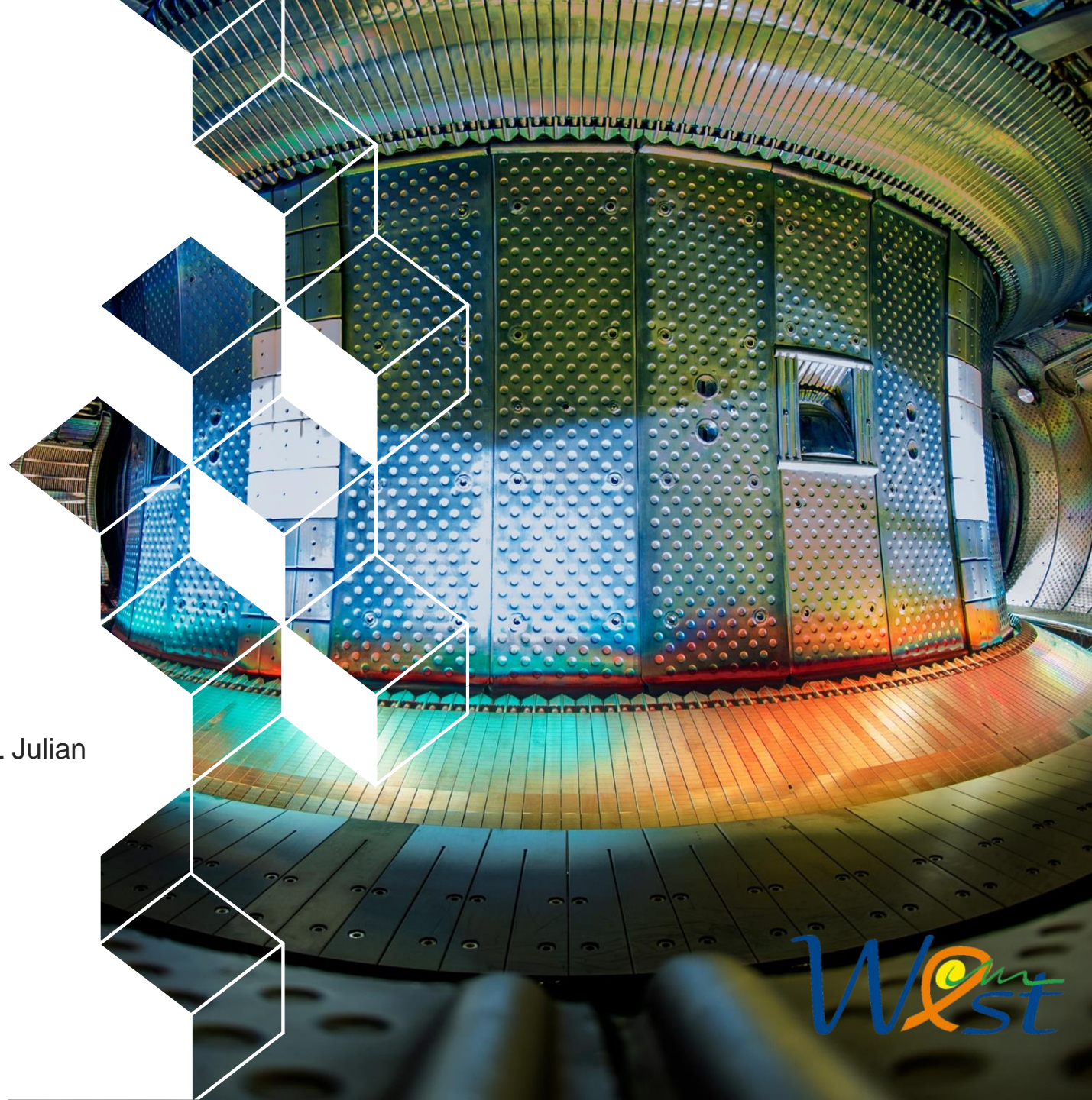
irfm



Optimizing tokamak operations using Machine learning methods as a service

ALMUHISEN Feda , MIDOU Dorian , FLEURY Ludovic, COLNEL Julian

Speaker: Feda ALMUHISEN



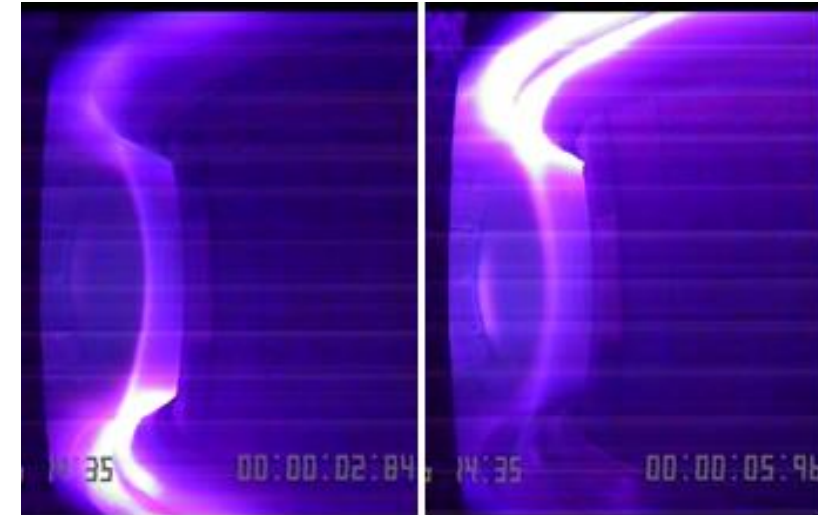
Outline

- 1. Our Team and Expertise**
- 2. The need for ML in Tokamak operations**
- 3. Our Approach : Local Artificial Intelligence-as-a service (WEST AI-aaS)**
- 4. WEST-AI services**
- 5. Future Directions and Conclusion**

1 ■ Our Team and Expertise

IRFM - WEST

- **WEST is dedicated to the mastery of nuclear fusion and fatigue-tests the ITER actively-cooled tungsten divertor components**
 - There are 1 to 2 experimental campaign per year
 - An experimental campaign represents up to 1 000 pulses
- **Up to 50 diagnostics**
 - Videos, Langmuir probes, spectroscopy, ...
 - Data volumetry is up to 6Go per pulse experiment
- **IT infrastructure**
 - Acquisition servers
 - Data pre-treatment servers
 - Databases



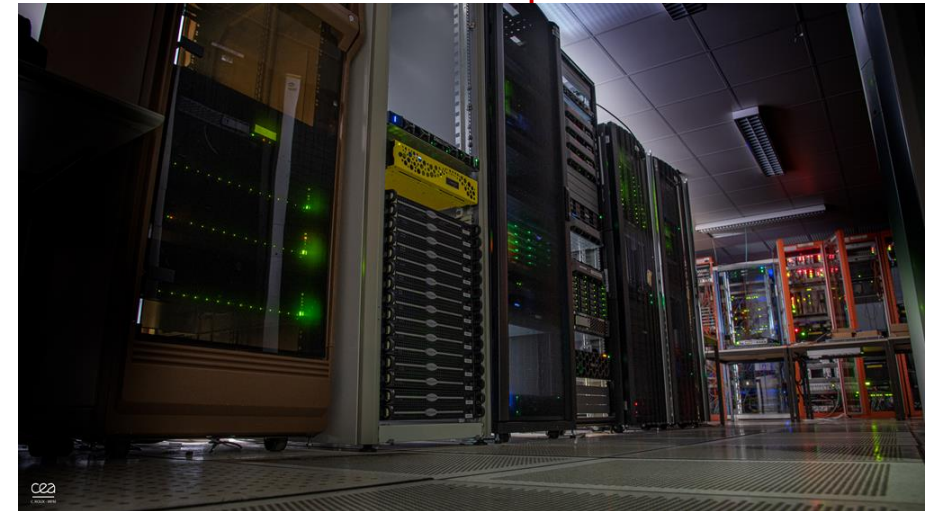
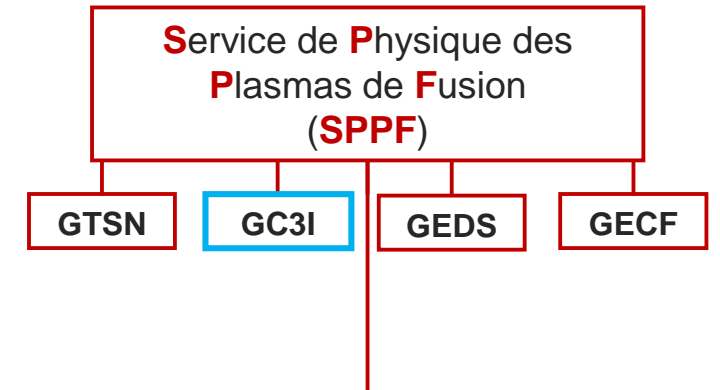
Lower & upper single null discharges in WEST tokamak during the last experimental campaign

➤ **GC3I team in charge of maintaining the IT operational readiness**

GC3I team at IRFM (HPC & IT infrastructure team)

GC3I :Calcul Intensif et Infrastructures Informatiques

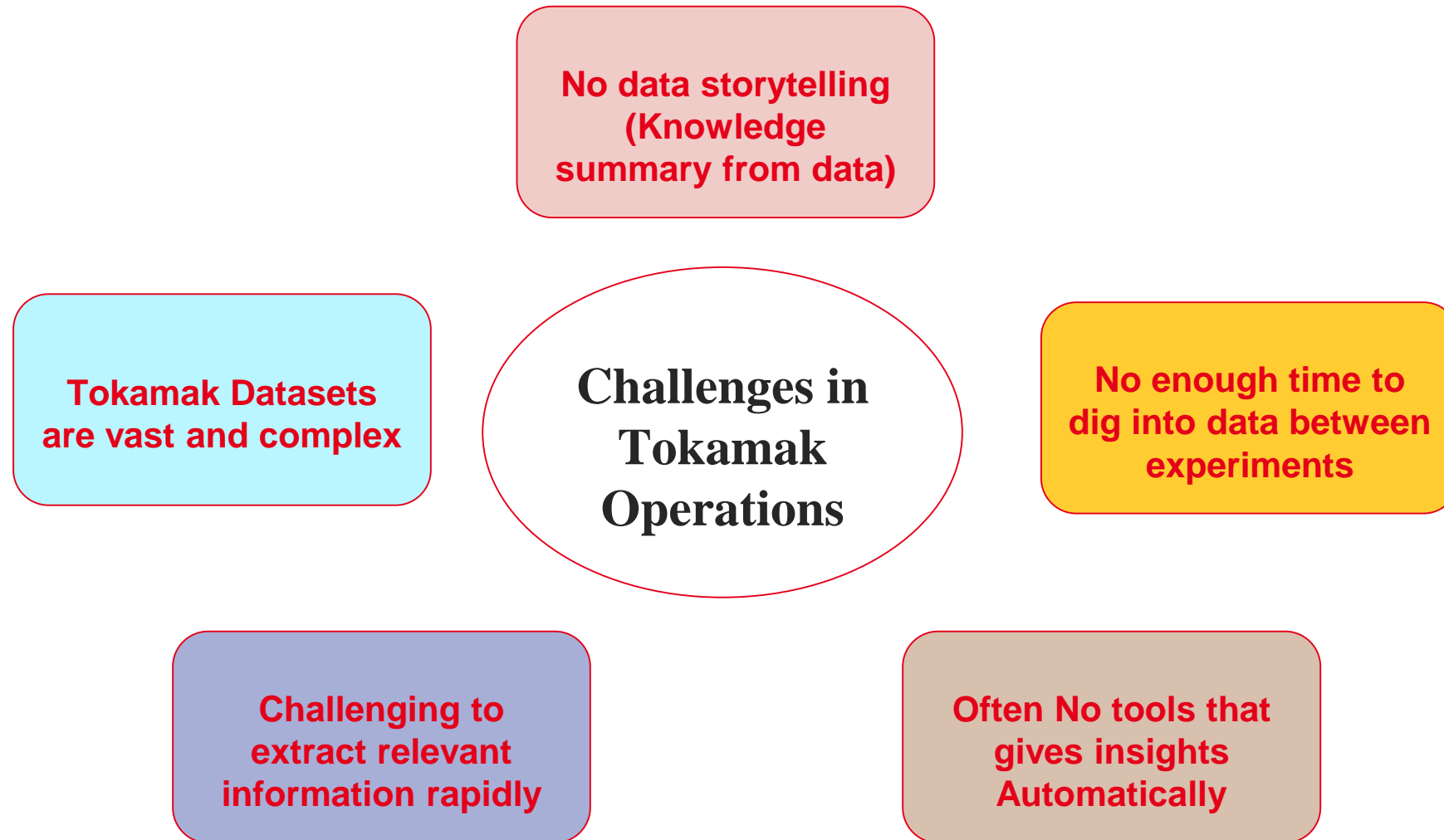
- Our team is composed of 7 permanent research engineers. They help the IRFM researchers in the following areas:
 - **High-performance computing (HPC)**
 - Optimization of simulation codes
 - **IT infrastructures**
 - **Applications development**
 - **Data processing** (experimental & simulated)
 - **Development and deployment of new AI models** applied to fusion



IT server room : 17 servers for a total of 596 compute cores and 7 GPGPUs dedicated to tokamak data analysis and simulations

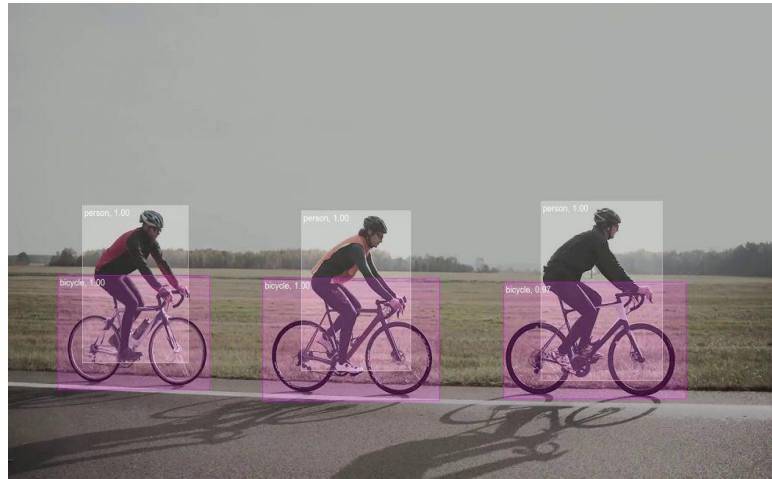
2. The need for ML in Tokamak operations

Problem statement:



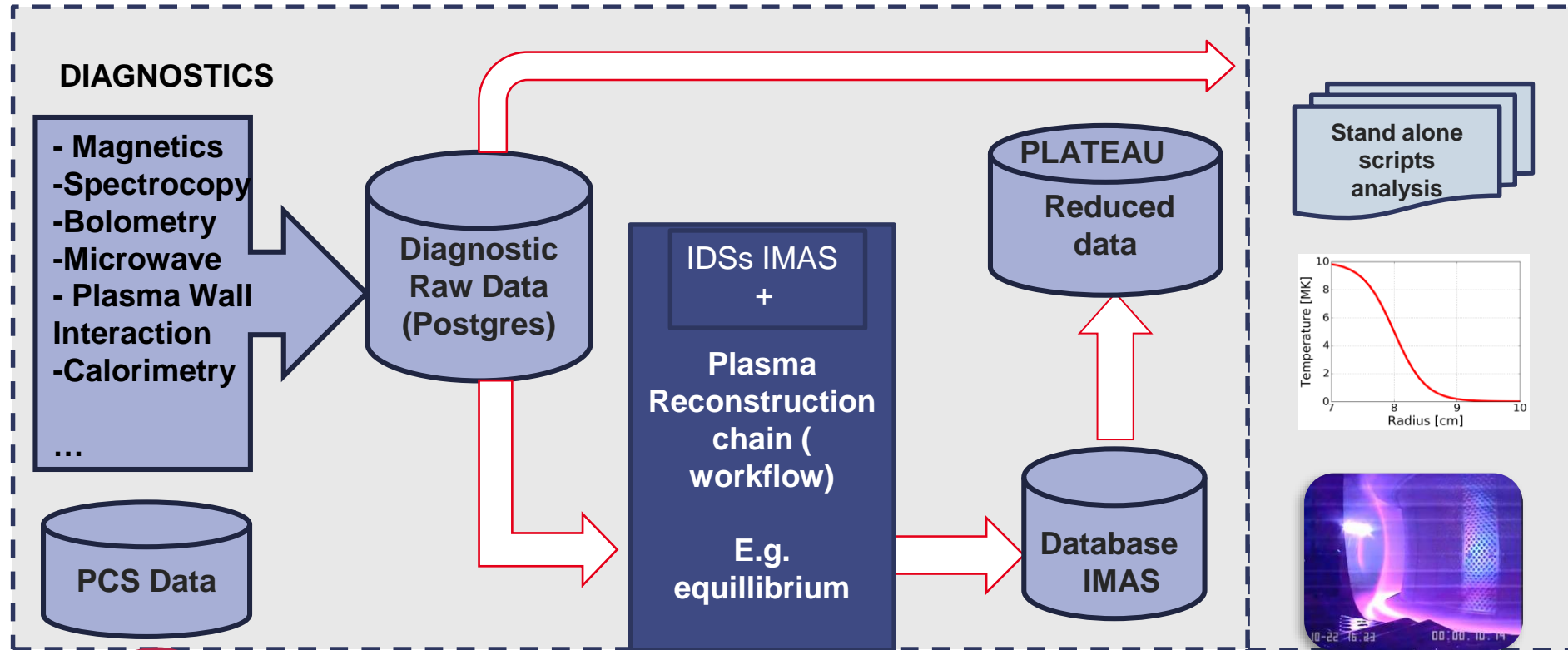
AI Potentials in fusion Research

1. AI can help to improve **data analysis** and modeling in fusion research
2. AI help in **identifying patterns** and relationships in large and complex datasets
3. Optimise fusion experiments design and help researchers in **decision making**.



Current Data Pipeline at WEST

MEASUREMENTS



- *Difficulty to aggregate data from multiple resources at different time scale.*
- *No unified standard datasource for AI*
- *Hard to understand the relationships between different datasets and to create useful features.*
- *No labelled dataset*
- *No trained models*

Data is Available after ~ 20 minutes after the end of shot

3 ■ Our Approach : Local Artificial Intelligence- as-a service (WEST-AI-aaS)

Towards WEST AI as a service project



Project Goals

- Approching real time data acquisition for applying AI algorithms
- Provide a dedicated AI Database that can be easily accessed
- Priorities performance optimization for AI/ML workflows
- Support analysis codes/libraries and ML/AI frameworks
- Support parallel computation

AI Data

Time series Data
Video data (2D+t)
Meta Data

AI Compute

Batch Processing
Online Processing

AI Services

Shot Annotation
Construct DB
Detection and Prediction
Reproduce AI methods applied on other Tokamak

AI Tools

jupyter hub
Python
Frameworks
(Tensorflow,
pyTorch ..etc)

WEST-AI-aaS proposed Architecture



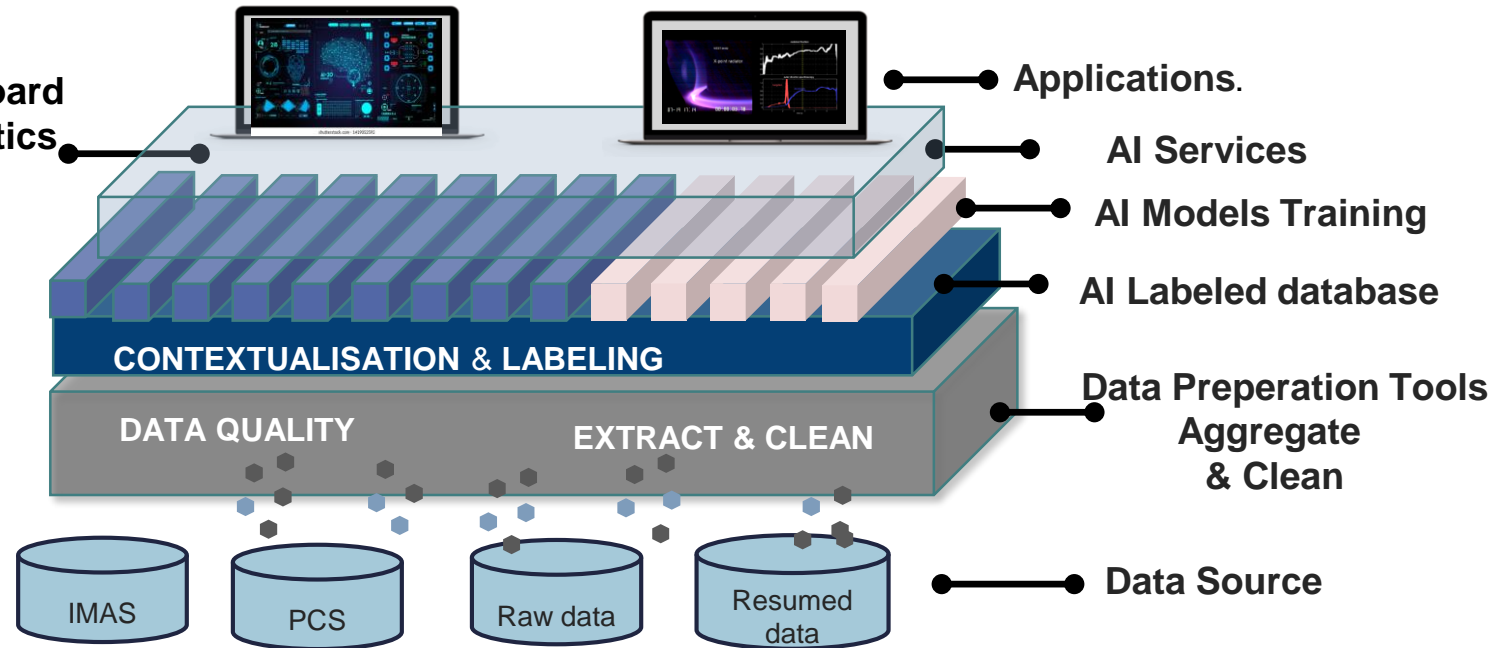
WEST_AIaaS

We propose a system architecture and services.

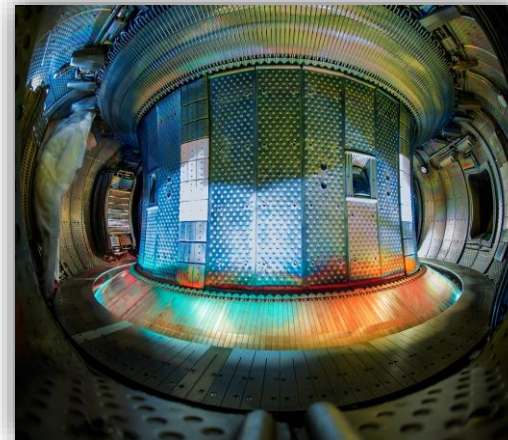
Which offers an end to end solution that customized artificial intelligence services for WEST data

Application :
Analytics dashboard
Predictive Analytics

Analytics Workflow



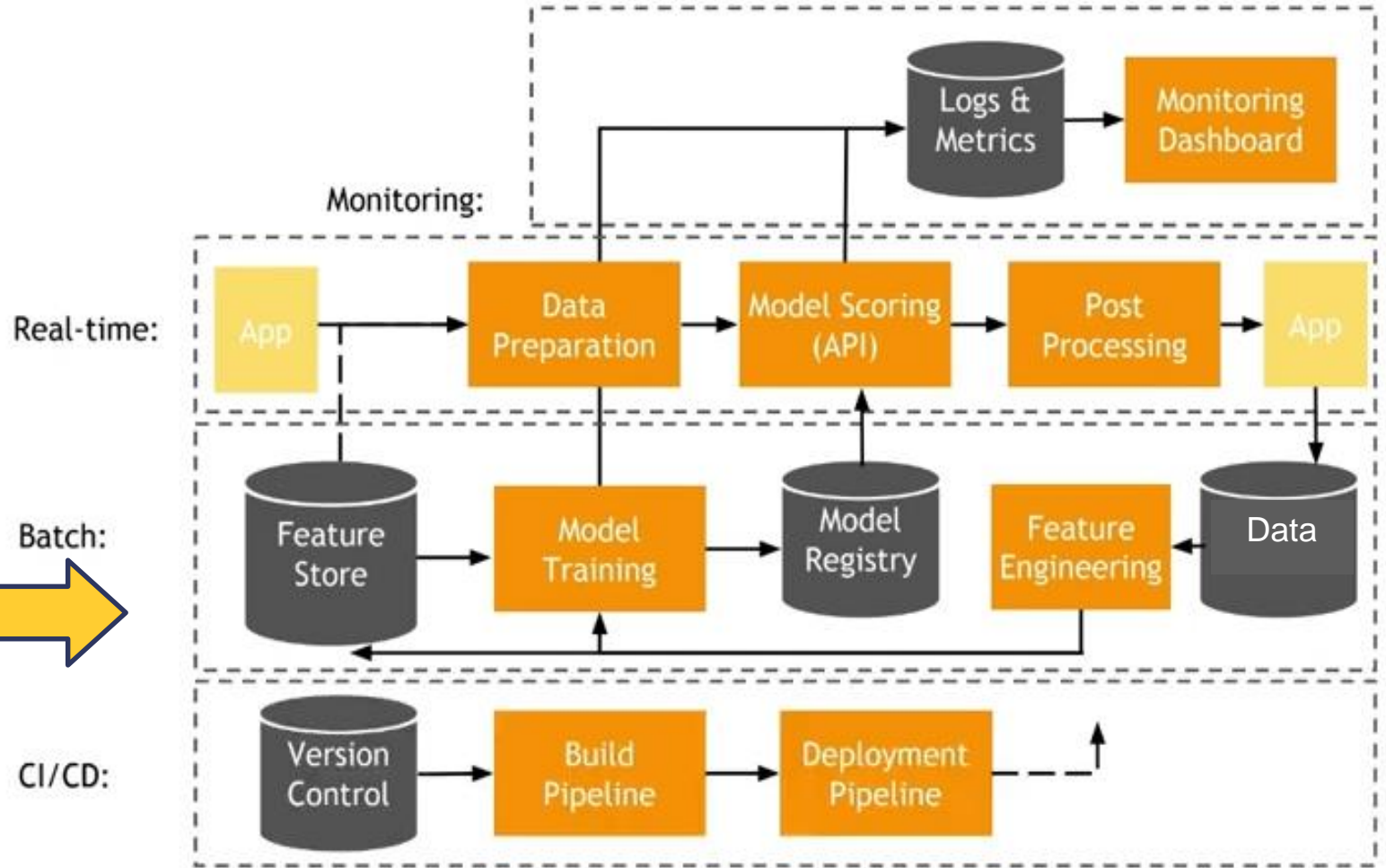
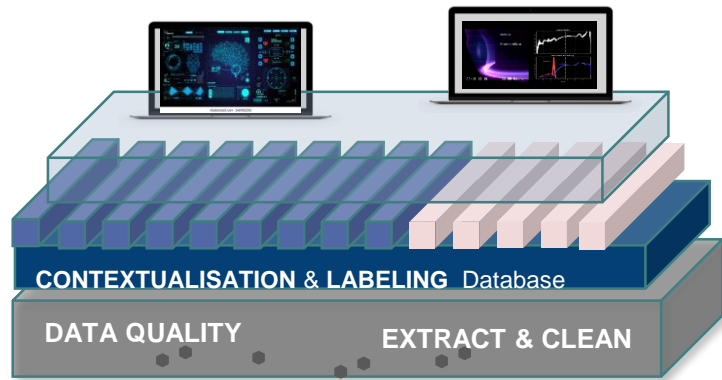
Accelerating the data collect during and after shot



WEST-AI-aaS Data Flow Diagram



AI Operations Pipeline



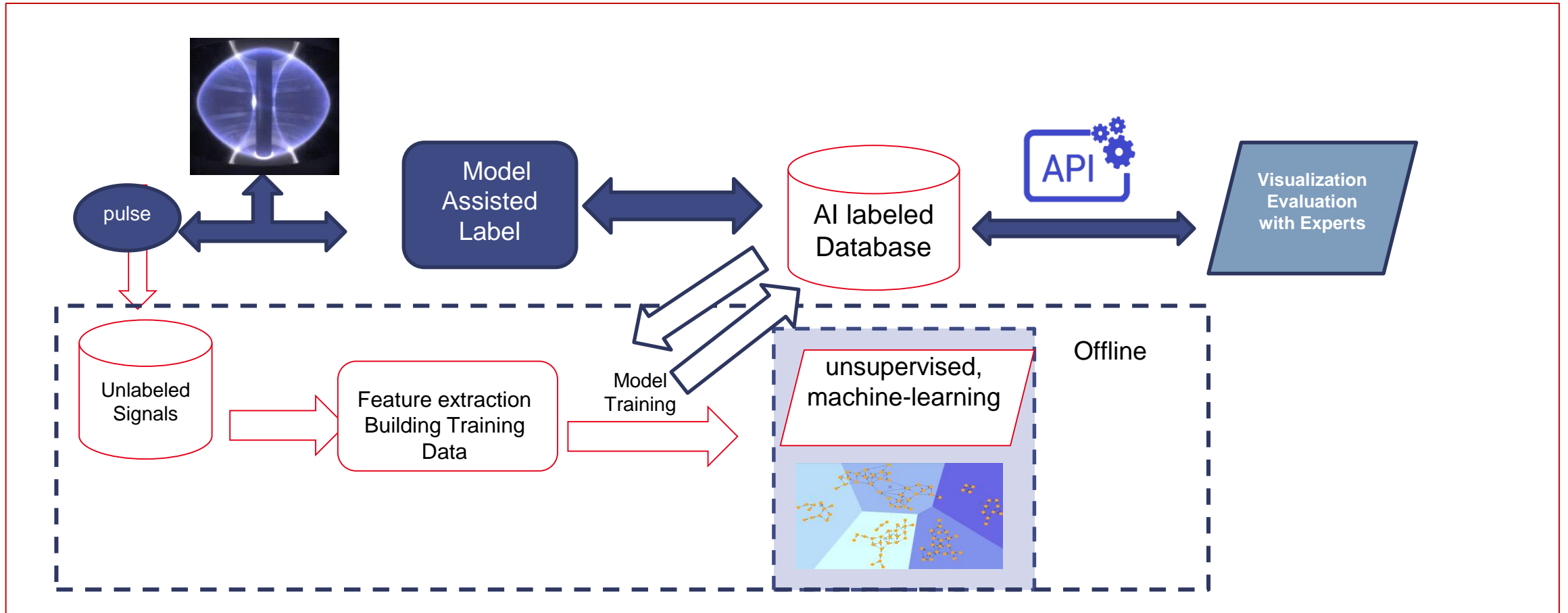
4 WEST-AI services Example

Model assisted labeling service

Work in progress

- AI Database

- Data contextualization



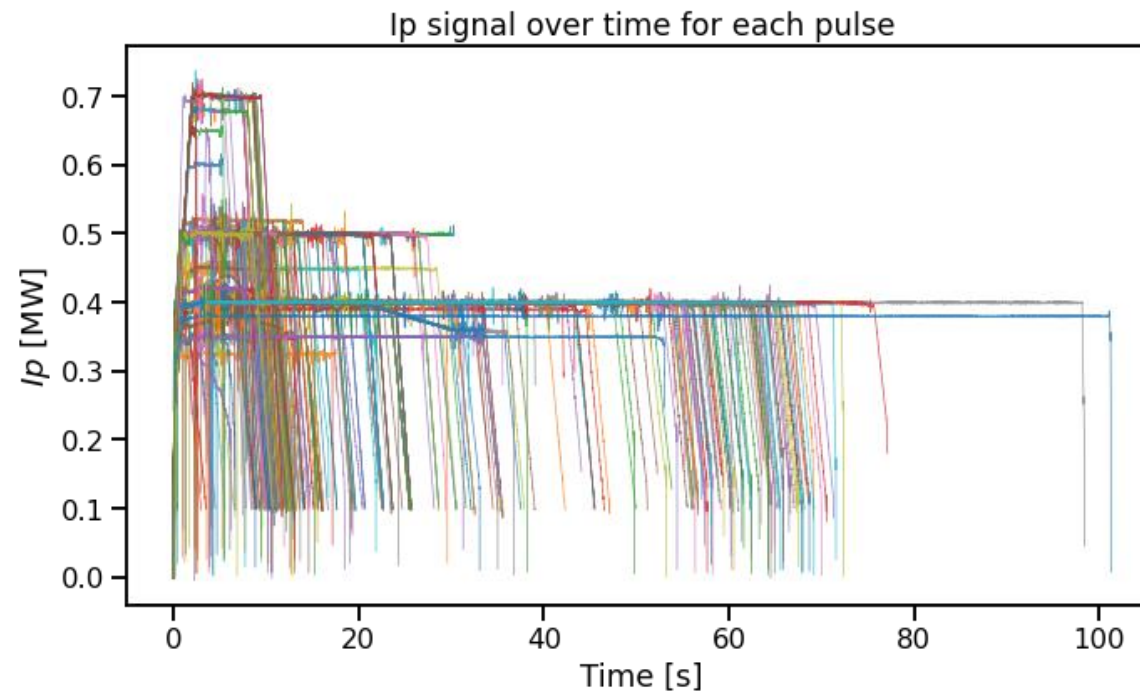


Model assisted labeling service (Example Visualisation)

Goal : differentiate and identify signals similarity in database for future categorizing and data analysis

Method tested: Dynamic Time Warping (DTW) and K-means clustering to find similarities among shots in database

Data : Signals collected from experimental campaigns WEST C7 in 2023 randomly





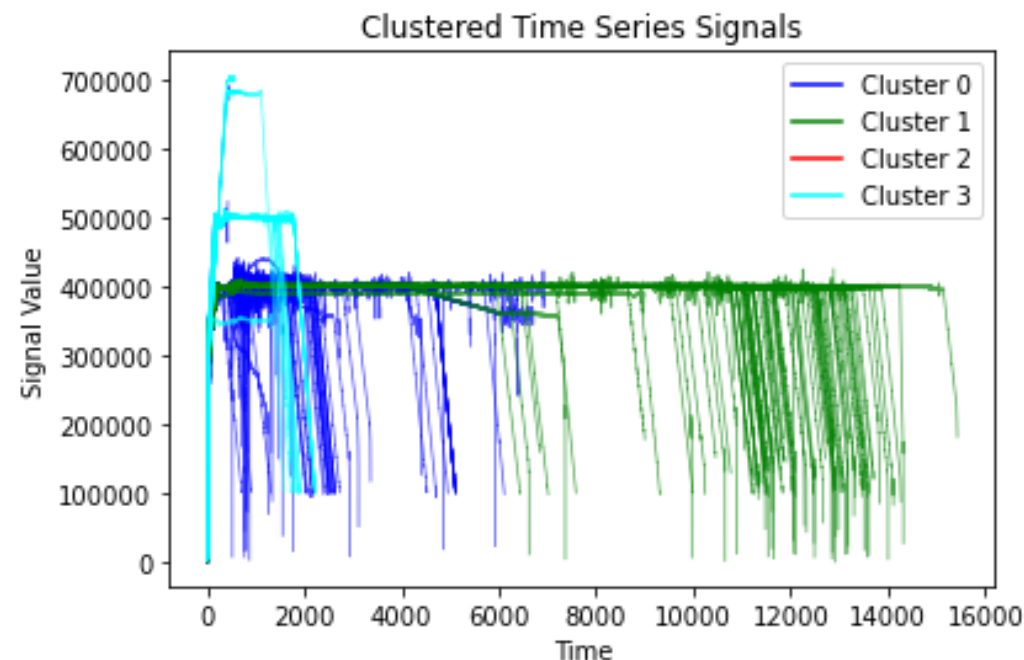
Model assisted labeling service (Example Visualisation)

DTW: is a method that allows to extract shape-based similarity measure for time series data and supports non-equal-length time series.

In our context, it can help identify similar shots signals for example the Ip current signal .

K-Means is clustering algorithm. that can group shots based on their similarities, helping us to categorize our data based on time and shape.

**K means and DTW
Preliminary result, But
encouraging !**



WEST AlaaS services



FUTURE

AI Pre-trained Machine learning algorithms and AI models access without requiring advanced programming skills

Event AI large language Models (LLMs) assistant

Automated targeted data analysis for WEST users

User interfaces for data analysis / visualisation

5 ■ Summary Conclusion Future Directions

Challenges in Implementing AI as a Service



– Challenges Ahead

The road to fully integrating AI into fusion experiments is filled with significant challenges, from handling complex data and developing accurate models, to integrating AI into tokamak operations.

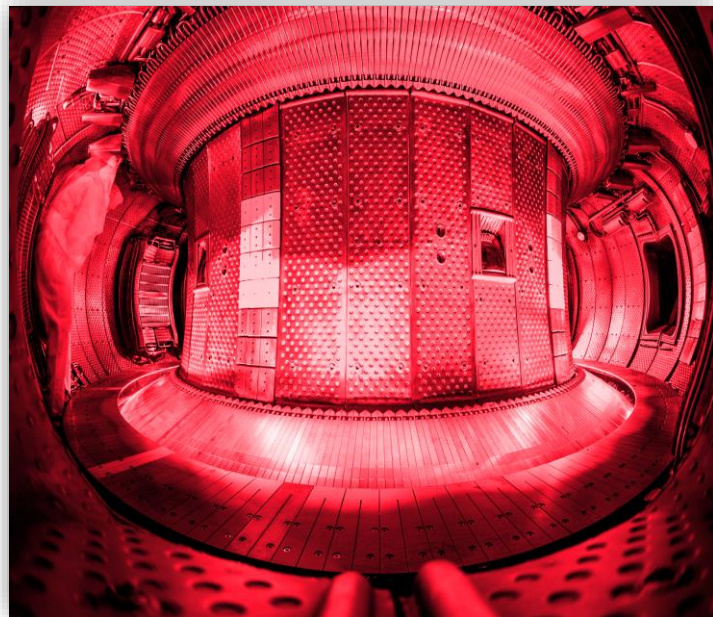
– Ongoing Efforts :

A new pipeline for building AI database has been proposed

An acceleration for the Time of data have been achieved

Thank you for your attention!

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Any questions ?

