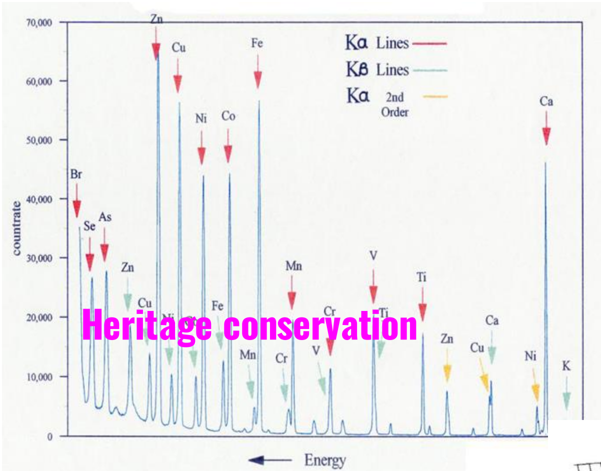
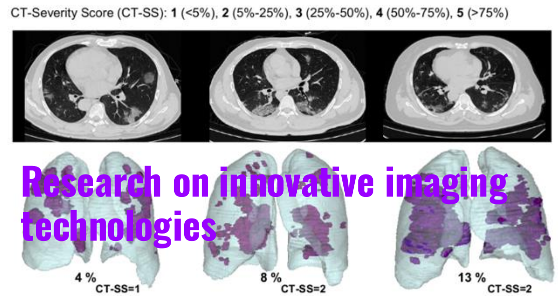
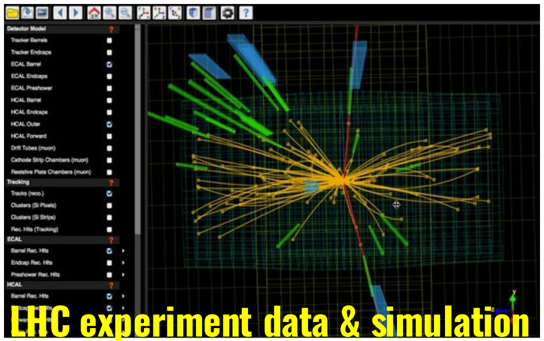
INFN and AI

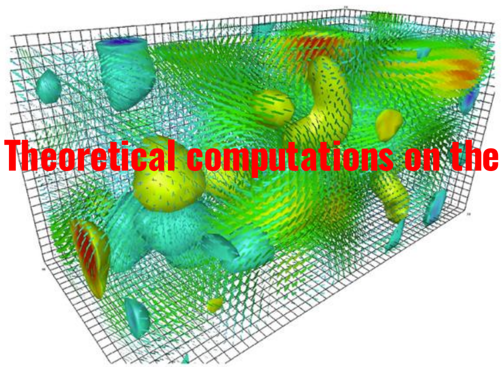
An obvious introduction

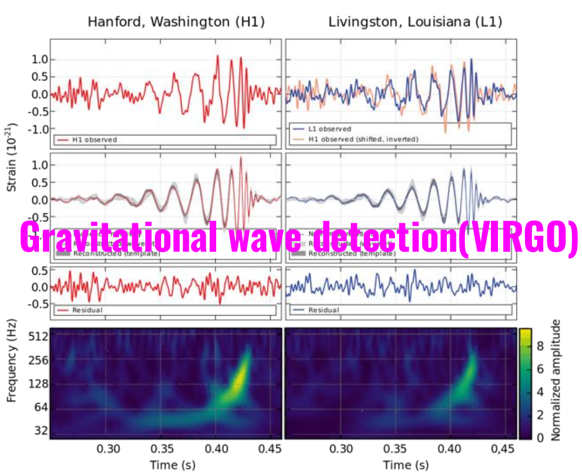
- AI/ML is used by researchers/technologists in several contexts
  - ML techniques are applied in analysis of data from HEP experiments to improve the identification of rare phenomena
  - AI is widely used in areas of applied physics such as detector design, biomedical applications, and the preservation of Cultural Heritage
  - Prototype AI systems are being tested for IT management tasks, including user support (help desk automation) and anomaly detection
  - Medium-long term project to develop AI tools to support/complement the work of administrative staff

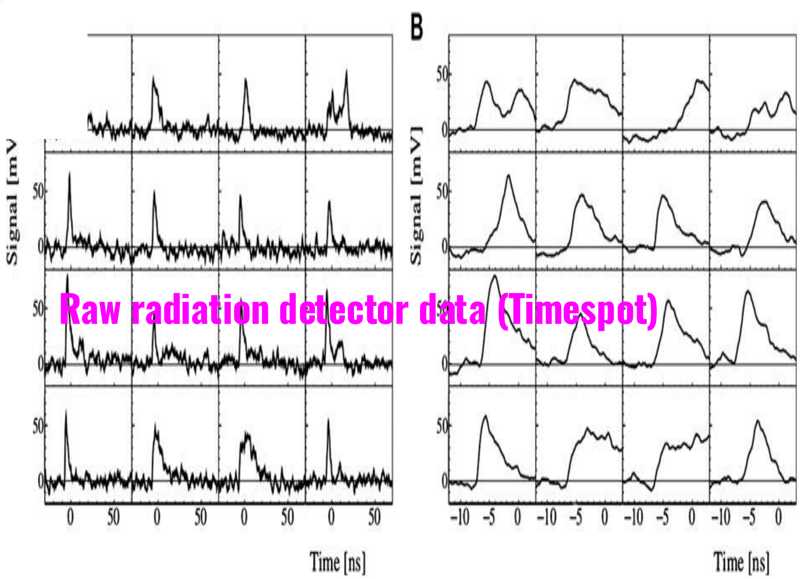

Heritage conservation
Kα Lines
Kβ Lines
Kα 2nd Order
countrate
Energy


CT-Severity Score (CT-SS): 1 (<5%), 2 (5%-25%), 3 (25%-50%), 4 (50%-75%), 5 (>75%)
Research on innovative imaging technologies
4 % CT-SS=1
8 % CT-SS=2
13 % CT-SS=2


LHC experiment data & simulation


Theoretical computations on the lattice


Hanford, Washington (H1)
Livingston, Louisiana (L1)
Strain (10⁻²¹)
Gravitational wave detection(VIRGO)
Frequency (Hz)
Normalized amplitude
Time (s)


B
Signal [mV]
Raw radiation detector data (Timespot)
Time [ns]

An example: Anomaly Detection

Case Studies:

- CNAF Data Center
- ENI plant for petroleum extraction

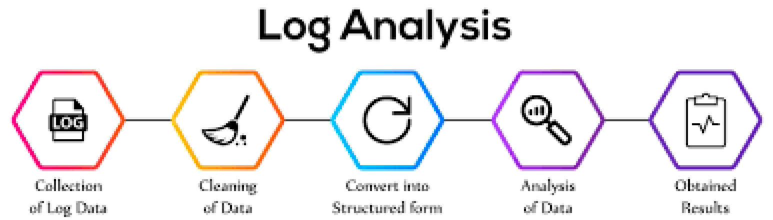
Approaches for monitoring data:

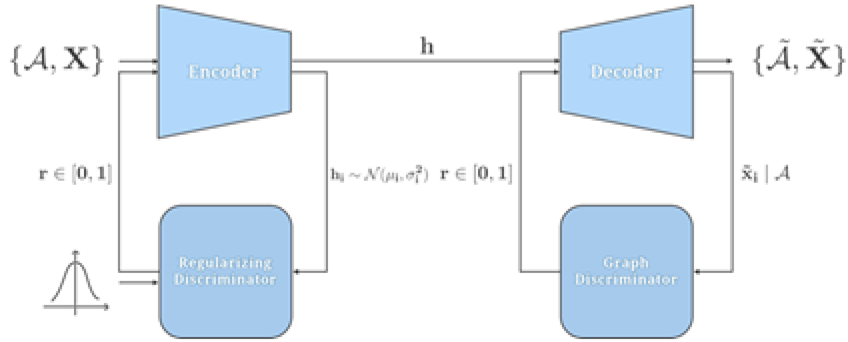
- Traditional Machine Learning Techniques, both supervised and unsupervised
- Graph Neural Network and Generative Adversarial Network

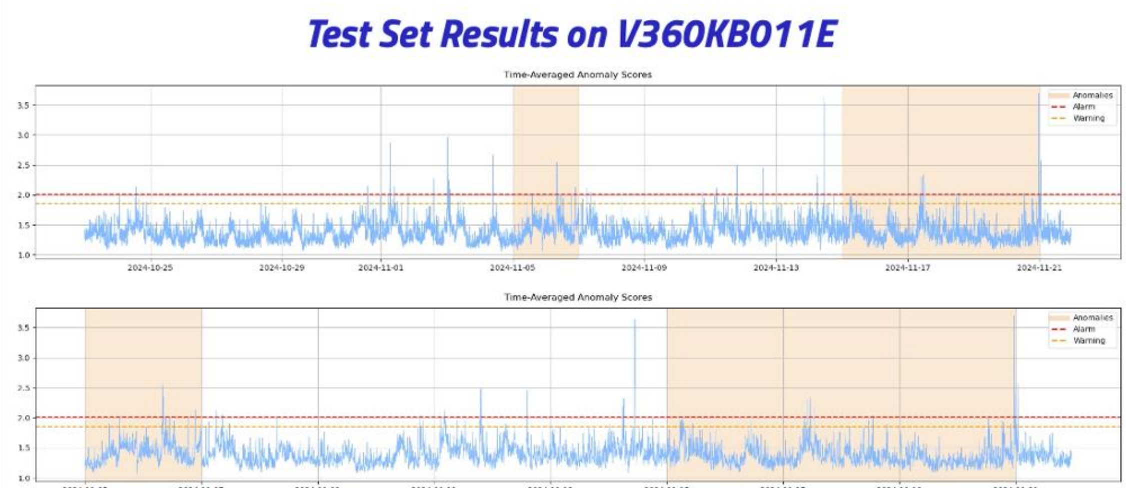
Approaches for process log files:

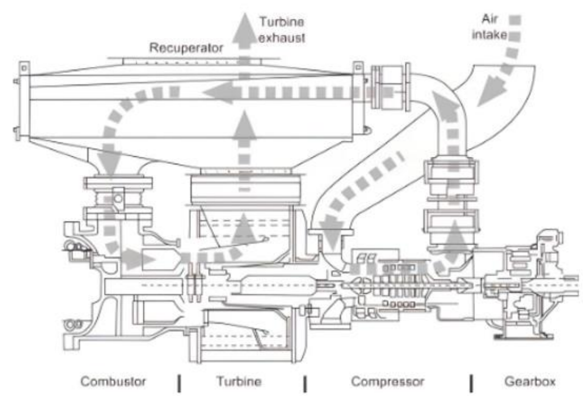
- Natural Language Processing Techniques

All studies documented in literature.









Courtesy of Elisabetta.Ronchieri@cnaf.infn.it

EU, AI and INFN (1/2)

- Significant push by the European Commission for investments for AI development/adoption
  - "CERN for AI" (U. Von der Leyen)
- Definition of a legal framework for AI approved (AI Act)
  - INFN participation (F. Lizzi) in the group for the General-Purpose AI Code of Practice (F. Lizzi) to support the implementation of the AI Act, specifically for general-purpose AI models
- Huge investment on AI by EU Commission (InvestAI: 200 G€)
- Create a CERN-like ecosystem for AI, combining public funding, private investment, and scientific excellence

EU, AI and INFN (2/2)

- Part of the EU investment is dedicated to building large-scale AI computing infrastructure, with the goal of giving Europe sovereign AI capabilities that support both researchers and enterprises
  - AI factories
  - AI Gigafactories
- The detailed definition of the strategy is still in progress, and INFN is committed to contributing actively to its development
  - Position paper on AI
  - Preparation of responses to 10 surveys is currently underway

IT4LIA

- IT4LIA (Italy for Leading Innovation in AI) proposal has been selected as one of the AI Factories
- Consortium led by CINECA, with ICSC as a participating member
  - INFN is also contributing the the project with focus on data management
- The AI Factory will be installed at the Tecnopolo
  - To be evaluated how (if possible) to use it as “standard” computing resource for INFN experiments
- Connects researchers, developers, startups, SMEs, public administration, and academia

AI Gigafactories

- Central part of the EU strategy to become a global leader in AI and close the technological gap with the US and China
  - Support the implementation of the EU AI Act
- Integrated with EuroHPC JU
  - Distributed across EU member states
- Focus on green AI and sustainable supply chains
- Public-Private Partnerships
  - Collaboration between governments, academia, and industry
  - i.e. the funding model includes significant private sector participation

INFN strategy on AI (1/3)

- A document has been submitted to the European Commission stating our strategy on AI
  - The paper is available **here**
- *With the contribution of:*
  - ***L. Anderlini, C. Bozzi, F. Lizzi, A. Retico, R. Torre***
- *Supervised by:*
  - ***T. Boccali, G. Carlino, L. dell'Agnello***
- *Approved by:* ***GE***

INFN strategy on AI (2/3)

- INFN supports initiatives on foundational AI and Quantum ML
  - Theoretical foundations of AI, and ML in particular, intersect with the study of complex systems, employing tools ranging from statistical methods to mathematical physics
  - QML applied to simulation of quantum systems (e.g., for high energy collisions and particle physics detectors simulations)
- Support the creation of a pan-European AI ecosystem
  - Align with EuroHPC Joint Undertaking and AI-tailored e-Infrastructure
  - Establish Centers of Excellence (CoEs) for research and societal applications
- Promote interoperability through standardized authentication and federated computing/storage resources

INFN strategy on AI (3/3)

- We believe that cross-fertilization with external entities (industrial partnerships too) is important too
  - E.g., common project with ENI on predictive maintenance in the framework of ICSC
- INFN also collaborates with national and international partners on AI-related projects
  - FAIR (National project on AI with other research entities and universities)
  - EuCAIF (Eu Coalition for AI in Fundamental Physics) in JENAA framework
  - Activities in WLCG/HSF
- We stressed also the importance of training of young researchers to promote a pervasive use of AI within INFN's research domains.

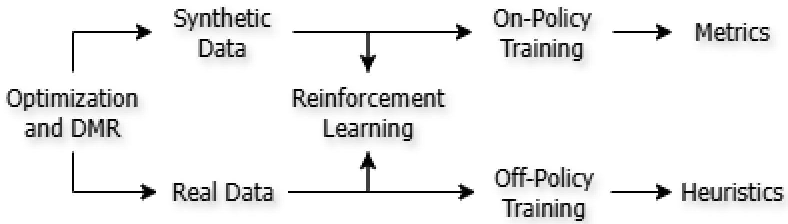
Optimization Issue

Case Study:

- ENI LNG optimization and prediction

Approaches:

- Reinforcement Learning Methods for optimization issue
- Traditional Machine Learning Techniques for prediction issue



Courtesy of Elisabetta.Ronchieri@cnaf.infn.it

AI_INFN

- Initiative to foster the adoption of ML and AI technologies
- Focus on
  - Creating a community of experts on AI sharing know-how on in the application of ML to research in physics
  - Building an infrastructure for AI on top of Datacloud leveraging on resources in INFN data centers (accessible as cloud resources)
    - Generic GPUs
    - HPC Buccles
    - HPC access (Leonardo, LISA, Marconi, Vega, ….)
  - Testing the usage of FPGAs for ML algorithms

AI_INFN: project structure

WP1 — Infrastructure and Resource Provisioning

Lots of resources coming from ICSC and TeRABIT?
→ Less "*pressure for being in production*" on our farm
→ Opportunity for contributing to the provisioning model

Focus shifts towards R&D on the provisioning model, with a systemic view to ease ML workloads.

Needs for an updated and well maintained farm.

WP2 — Open Science and Advanced Education

What will be added-value in our *hackathons*?
→ ML_INFN has attracted a community of world-leading experts in the application of ML to research in physics
→ We can be more ambitious in the target of our *hackathons,* letting experts to discuss their code

Focus shift towards *Advanced Hackathon Workshops*.

AI_INFN
Artificial Intelligence technologies for INFN research
ai.cloud.infn.it

WP3 — Scientific use cases

Applications to scientific research remains central.

To develop the tools for making it easier to do machine learning for INFN researchers,
we need them to use the tools and provide feedback.

***How?* User support and community engagement**

WP4 — ML on FPGA and Quantum Computers

New hardware will change the landscape of computing.

Deploying ML algorithms of **FPGAs** enables fixed-latency, low-energy inference.
Quantum Computing will enable extremely fast computations of specialized algorithms.

Courtesy of Lucio.Anderlini@fi.infn.it

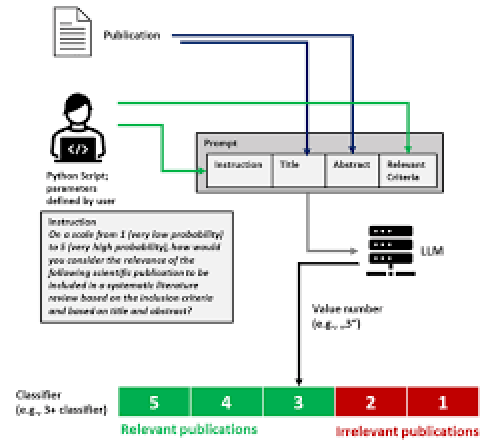
Short Text Analysis

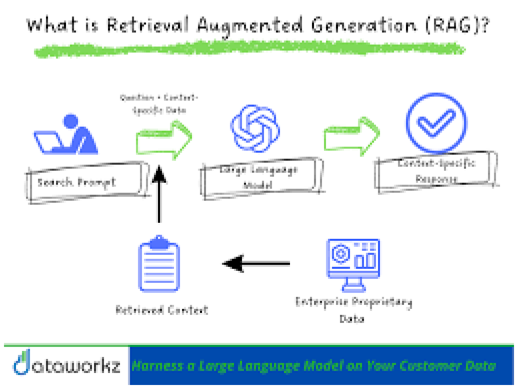
Case Studies:

- Tweet messages about vaccines, pandemic events, natural disasters and cultural heritage themes
- CNAF User Support emails
- Scientific papers' Abstracts and Titles
- Process log files

Approaches:

- Natural language Processing Techniques
- Large Language Models
- Retrieval Augmented Generation (RAG) solutions





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Other related activities

- AAMDA-2025 workshop at ICCSA 2025 – "Advancements in Applied Machine-learning and Data Analytics" (July 2025)
- Mini track at HICSS-59 - "Artificial Intelligence-powered Devices and Sensors" (Jan 2026)
- *Workshop on "AI challenges in Data Centers for HEP and beyond HEP" (still to be fully defined, likely date: Fall 2025)*