



# CRG opportunities for AI/ML apps

Potential applications and intentions, foreseeable investment

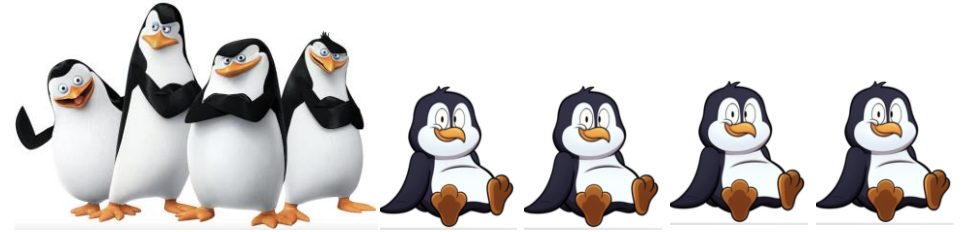
Presented by L. Serio on behalf of the CRG group for brainstorming at TE-TM

Monday 9<sup>th</sup> of September 2024

# TE-CRG Projects portfolio (ext. funded)

all covered by KT agreements approved by the ATS sector and TE department ✓ *with CRG technologies synergies*

- CAFEIN-FL - Federated Learning Platform ✓
- CAFEIN - Anomaly detection and prediction ✓
  - Brain pathologies screening
  - Breast cancer screening
  - IoT medical (EEG signals analysis) and industrial devices (CRG compressors vibration analysis)
- TRUSTROKE -Trustworthy stroke management platform
- UMBRELLA - Improved prediction, detection and treatment for comprehensive stroke management
- STELLA Smart Technology to Extend Lives with Linear Accelerators ✓
- Market Intelligence Platform with WHO to model, predict and improve resilience of supply chains ✓



# Recognized technologies expertise & infrastructures

**Based/benchmarked on novelties and number of published results, assessment of funded projects, impact and implementation on real world applications**

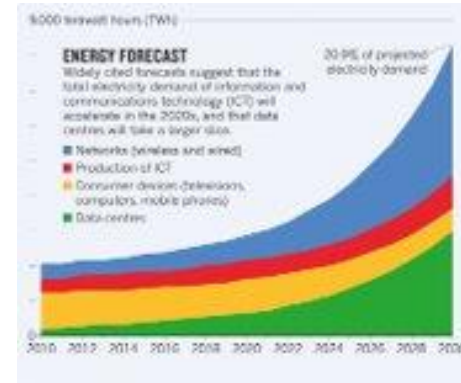
- FEDERATED LEARNING – TE-CRG
- FEDERATED LEARNING AGGREGATION ALGORITHMS – TE-CRG
- FEDERATED LEARNING OPERATING PLATFORM – TE-CRG
- NETWORK and COMMUNICATION SECURITY – IT
- OPERATION OF COMPLEX and SECURE IT INFRASTRUCTURE - IT
- GRAPH NEURAL NETWORKS for complex problem solving and modelling – TE-CRG

# TE-CRG

## Potential applications & intentions with funding proposal

### CAFEIN Platform for AI/ML developments and training (technology and platform):

- Federated Learning Platform sustainability analysis and long-term decision on CERN role (developer, operator, open-source, KT) – TBA with KT and ongoing projects
- Carbon tracker and optimise – waiting KT funding/other call - **1 PhD and 1 ORIGIN**

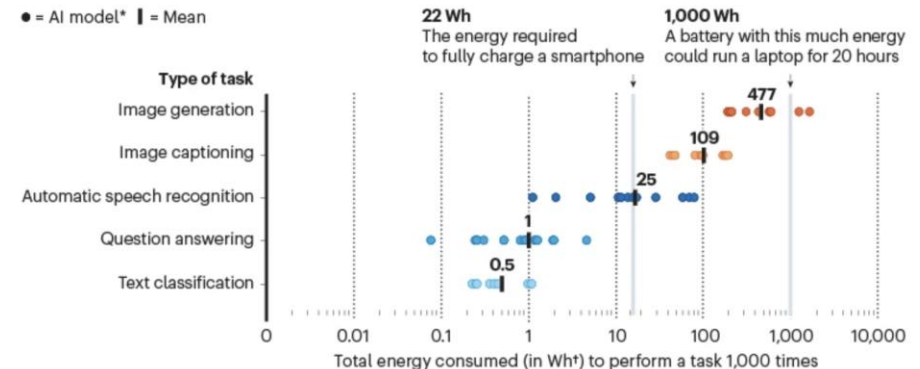


### Large centralized data centers for AI and big-data analytics

- 15% of the global Green House Gas (GHG) emissions of Information and Communication Technology ecosystem
- Contribute to about 0.3 % of global CO<sub>2</sub> emissions

### AI'S ENERGY FOOTPRINT

The power consumed by artificial intelligence (AI) tools varies greatly depending on the task. An AI model that provides answers to queries is much less energy-intensive than one that generates images from text prompts, for example. And the data show that even AI models of the same type can vary widely in energy consumption.



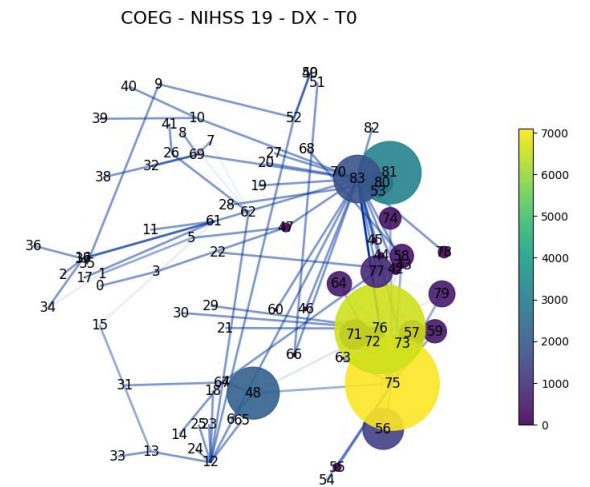
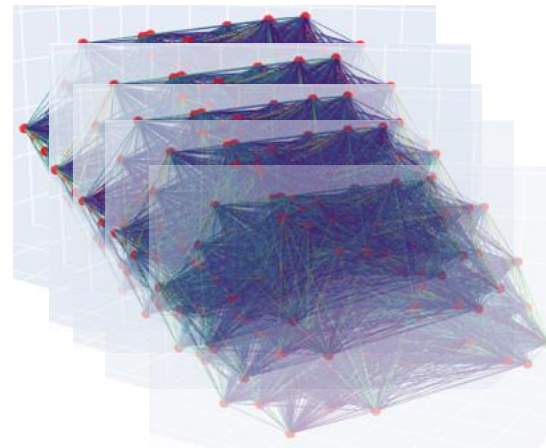
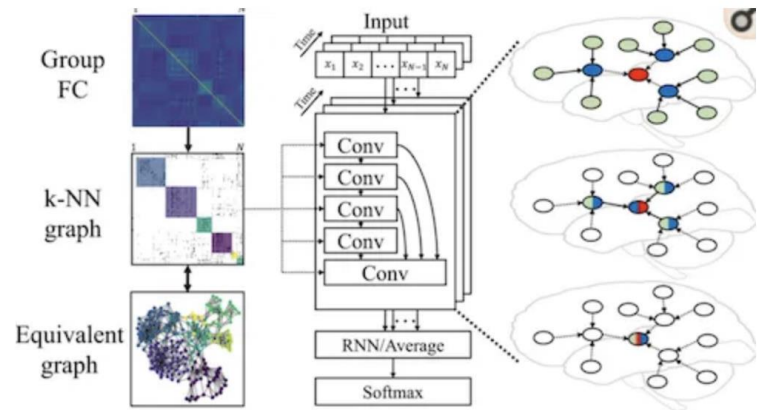
Source: Unpublished analysis by S. Luccioni *et al.*/AI Energy Star project

# TE-CRG

## Potential applications & intentions with funding proposal

### Medical technologies:

- GNNs for brain functionalities modelling (management of pathologies, diagnosis, prediction and prevention) – **KT funding for MA, new call 1 PhD**



# TE-CRG

## Potential applications & intentions with funding proposal

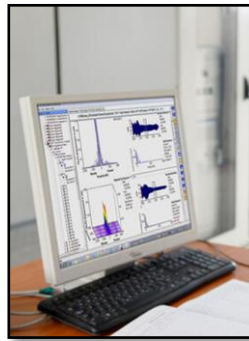
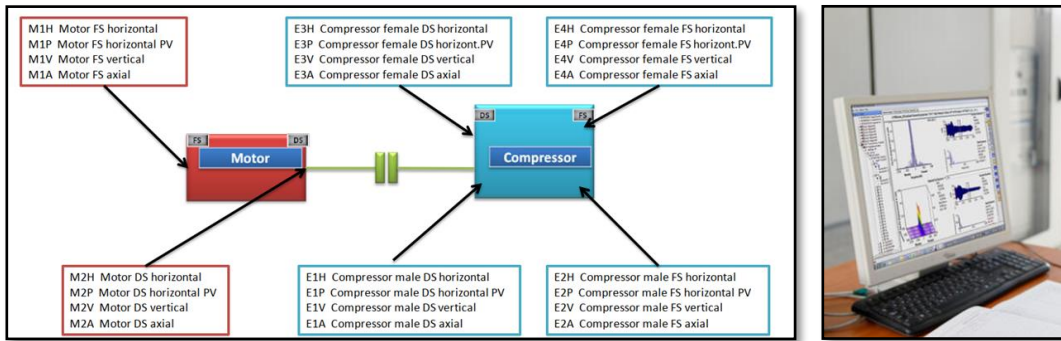
### Accelerator technologies applications implementation based on developments

- ML/AI expertise support funded from ext. funding
- Internal funding for implementation in TE-CRG - 1 FTE GRAD for 2 years (also PT share)
  - Complex systems simulations via data driven modelling (GNNs, autoencoder, NN, etc. for diagnostics, training, advanced controls)
  - Fault analysis, RUL and dependencies mining (GNN, autoencoder, APRIORI and genetic algorithm, etc. for prescriptive maintenance, diagnostics, resilient design)
  - LLMs to support maintenance and operation tasks (chatbot, reporting) to complete the development and implementation of the GNN models for use for diagnostic (digital twin), advanced controls and risk analysis (med & ind)
  - Applications implementation for prescriptive maintenance based on the developed/tested algorithms: e.g. anomaly detection and RUL for rotating machinery

# Prescriptive maintenance on IoT Federated devices

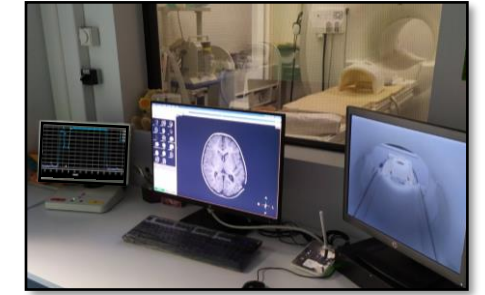
## Investigation for cryogenics application(s):

- AI powered - IOT Federated Learning infrastructure for prescriptive maintenance on cryogenics helium compressors.
- Carbon cost optimized architecture

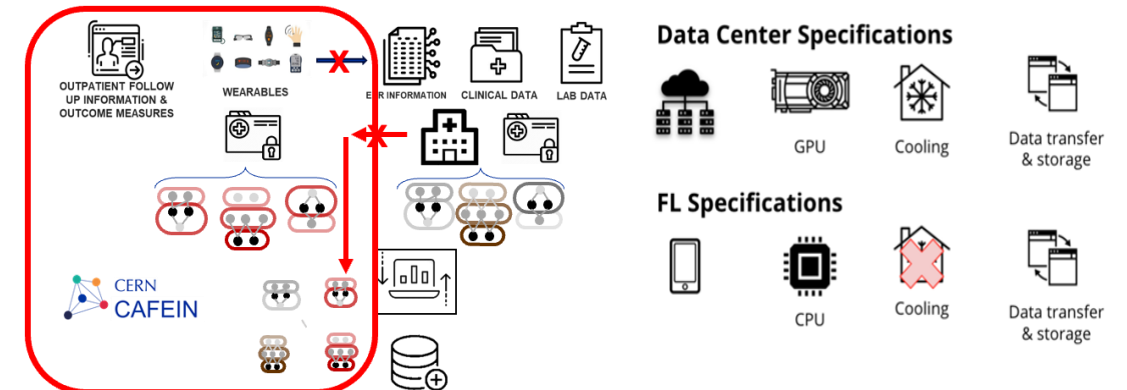
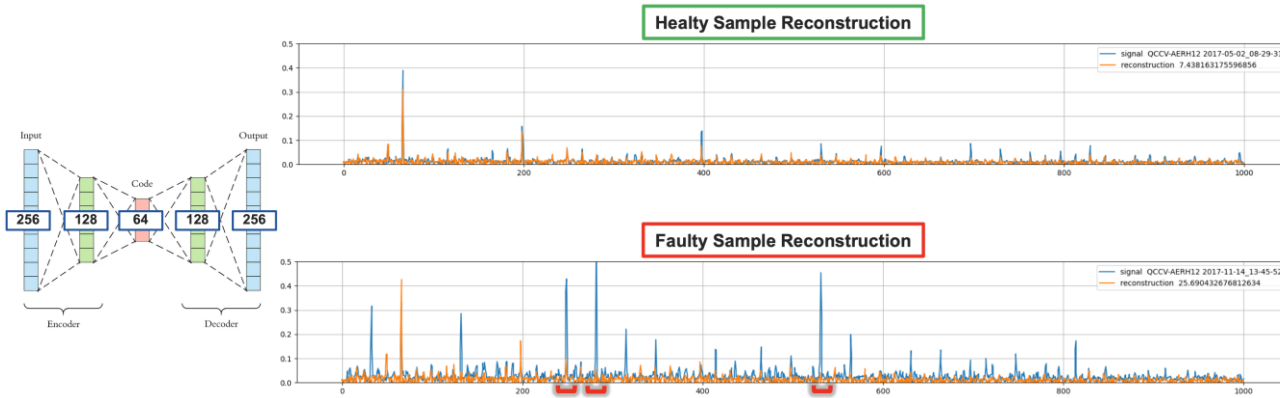


## Investigation medical application(s):

- Adaptation of the system developed for industrial applications to integrate it in the CAFEIN federated learning infrastructure.
- Optimization of software and development of dedicated hardware to optimize the system for medical use.



Technology Transfer



Ref.: A Carbon Tracking Model for Federated Learning: Impact of Quantization and Sparsification - L. Barbieri, S. Kianoush, M. Nicoli, S. Savazzi, L. Serio - [arXiv:2310.08087](https://arxiv.org/abs/2310.08087) - 2023 IEEE 28th CAMAD, October 2023  
 Ref.: Machine Learning Framework for Anomaly Detection and Maintenance Optimization in Large-Scale Cryogenic Systems – P. Cacace et al. - ICEC 2024 Geneva

# TE-CRG

## AI/ML “potential” future activities with developments

Similar resource requirements with synergies with other apps – **~ 2 FTE GRAD**

- Use of AI/ML techniques in some of the existing tools in the CRG group
- Support to operators for daily anomaly detection
- Support to maintenance activities and analysis of Infor EAM and NXCALS data and text (NLP)
- Support for functional and risk analysis study and validation
- Support for the design optimization for future cryo system (FCC, etc)
- Data reduction in NXCALS data to accelerate data retrieval and offline analysis (filtering)
- Use neural networks as equation solver for CFD or process simulations



# TE-CRG

## AI/ML tools and support

### Required support and tools

- HTCondor and Swan
- AFT and NXCALS (future add Infor EAM)
- 3 GPUs workstations for medical applications
  
- H2020 funding covers investment for hardware – infrastructure (medical apps)
- H2020 and WHO funding to cover new MPE resources for the medical projects

# AI/ML strategy inputs

- AI/ML competences shall be fostered in future to have educated (constant training) scientists in the matter
- No need to internalize or centralize most of the activities, the interest, competencies and know how is in the applications development and this is best managed within the equipment groups
- Keep existing collaborations and promote new in the interest of the activities/applications (and in particular seek external funding where CERN competences and infrastructure can be used to develop, test and deploy AI for society, indirectly will help create the resources for us)
- Maintain a minimum set of internal resources knowledgeable and constantly trained – this as a requirements to invest in training and allow / promote personnel to devote PT to AI
- Identify minimum required centralized (efficiency) support for tools, hardware and training

# TE-CRG

## AI/ML collaborations - all covered by KT agreements approved by the ATS sector and TE dept.

Internal and external existing or potential collaborations of interest

**TRUSTroke Project (H2020 funding) – 2023 – 2027**

**UMBRELLA Project (H2020 funding) – 2024 – 2029**

**STELLA Project (ICEC and DoE) – 2024 - 2025**

**WHO/IARC cancer screening platform (KT funding) – 2023 – 2026**

**WHO- MIP supply chain management for pandemics (WHO / EU) – 2024 - 2025**

**External labs:** Centro Nazionale delle Ricerche (CNR), IARC, WHO, Vall d'Hebron Hospital, Policlinico Gemelli, UKC Ljubjiana, Josef Stefan Institute, Stroke Alliance for Europe, + 30)

**Universities:** National and Kapodistrian University of Athens, Politecnico di Milano, BRNO University, La Sapienza Rome, UZ Leuven

