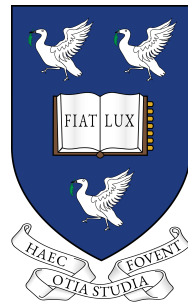
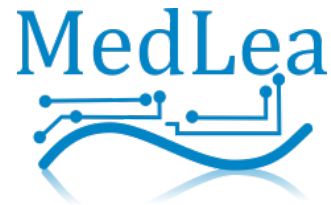


# MUCCA

## Multi-disciplinary Use Cases for Convergent new Approaches to AI explainability

CHIST-ERA Project Seminar 2022



CHIST-ERA-19-XAI-009



# The MUCCA Project

**Ultimate Goal:** *quantifying strengths* and *solving weaknesses* of new and state of the art xAI methods

different data, learning tasks,  
scientific questions

**Strategy:** study xAI in *heterogenous use cases* from High Energy Physics (HEP), medical imaging, diagnosis of pulmonary, tracheal and nasal disease, neuroscience

**Collaboration** that brings together researchers from different fields

- High Energy Physics
- Medicine
- Neuroscience
- Computer science



**Multidisciplinarity**

**Three phases:**  
1. Apply xAI techniques  
2. Identify shortcomings and metrics  
3. Get new transparent algorithms

# The Consortium

**Sapienza University of Rome (IT)**  
**Departments of Physics, Physiology,**  
**and Information Engineering**



Funding  
agency:  
MUR

HEP: data-analysis, detectors, simulation AI: ML/DL methods in basic/applied research and industry, intelligent signal processing. Neurosciences: brain encoding of **complex** behaviours, ML in electrophysiology, multi-scale modelling approaches

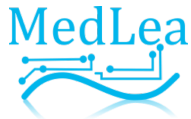
**Istituto Nazionale Fisica Nucleare (IT)**  
**Rome group**



Funding  
agency:  
INFN

Fundamental research with cutting edge technologies and instruments, applications in several fields (HEP, medicine imaging/diagnosis/prognosis/therapy)

**Medlea S.r.l.s (IT)**



Funding  
agency:  
MUR

High tech startup, with an established track record in medical image analysis and high-performance simulation and capabilities of developing and deploying industry-standard software solutions

**University of Sofia St.Kl.Ohridski (BG)**  
**Faculty of Physics**



Funding  
agency:  
BNSF

extended expertise in detector development, firmware, experiment software in HEP

**Polytechnic University of Bucharest (RO)**  
**Department of Hydraulics, Hydraulic**  
**Equipment and Environmental Engineering**



Funding  
agency:  
UEFIS CDI

Complex Fluids and Microfluidics expertise: mucus/saliva rheology, reconstruction and simulation of respiratory airways, AI applications for airflow predictions in respiratory conducts

**University of Liverpool (UK)**  
**Department of Physics**



Funding  
agency:  
UKRI

physics data analysis at hadron colliders experiments, simulation, ML and DL methods in HEP

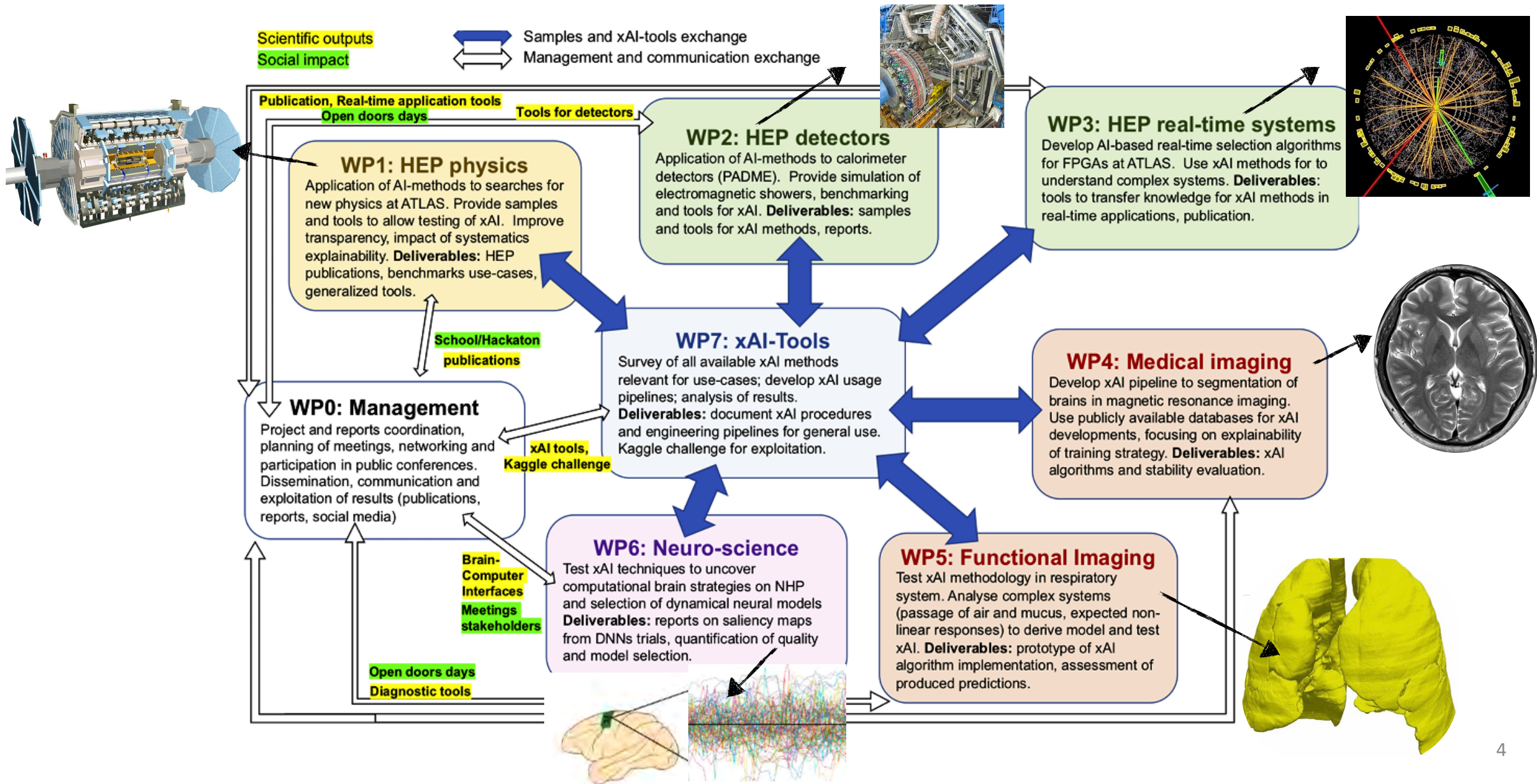
**Istituto Superiore di Sanità**



Funding  
agency:  
INFN

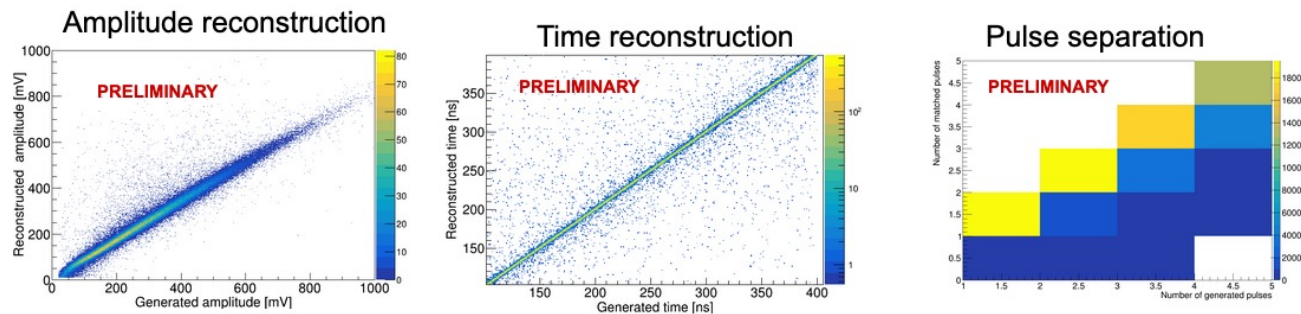
expertise in neural networks modeling, cortical network dynamics, theory inspired data analysis

# The Work Plan



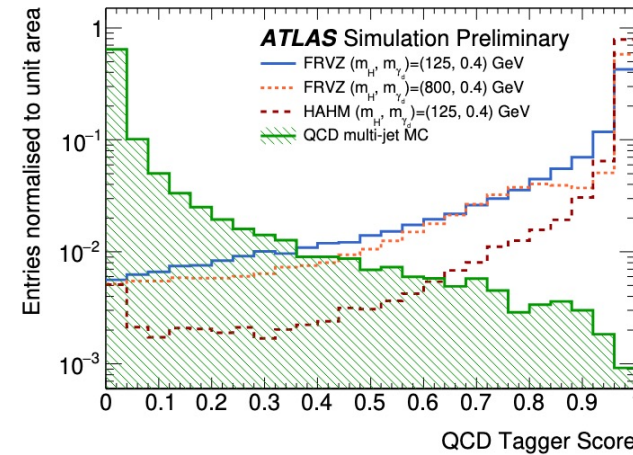
# Progress Report: HEP Uses Cases

**WP1:** *developed AI algorithms* (CNN, Graph NN), *targeted to event classification* and process discrimination, for new physics and dark matter searches at ATLAS. *First review of suitable state-of-art xAI algorithms* performed

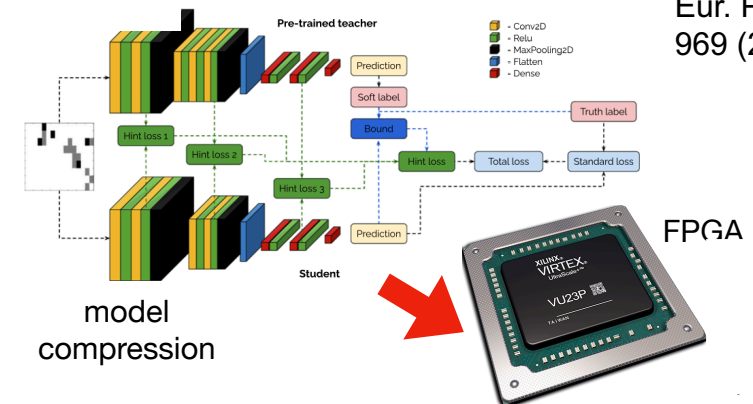


**WP3:** *developed complete pipeline for an AI based event selection* algorithm to expand physics potential of the ATLAS experiment. CNN model with compression and simplification strategies to make easier to interpret, and faster to execute the AI model, for the conversion and implementation in the firmware of FPGA accelerators. Obtained CNN inference in 80/150ns/image

Public report atlas-conf-2022-001



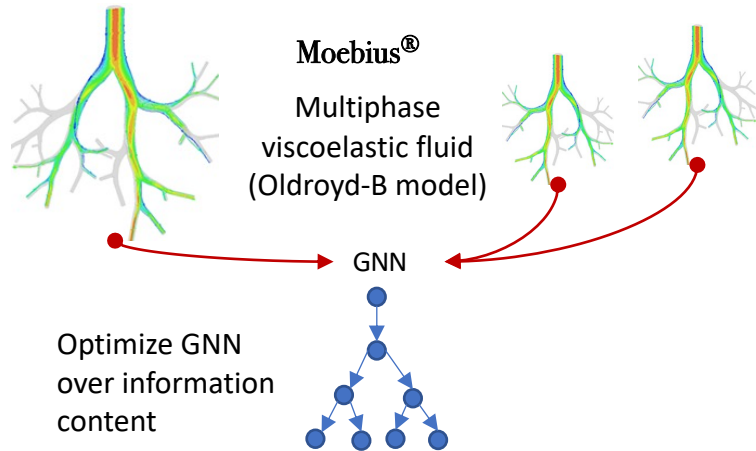
**WP2:** *AI algorithms* (CNN, autoencoder), *successfully developed* and applied to identify pulses, determining amplitude and time of arrival in close to reality simulated data of the PADME calorimeter



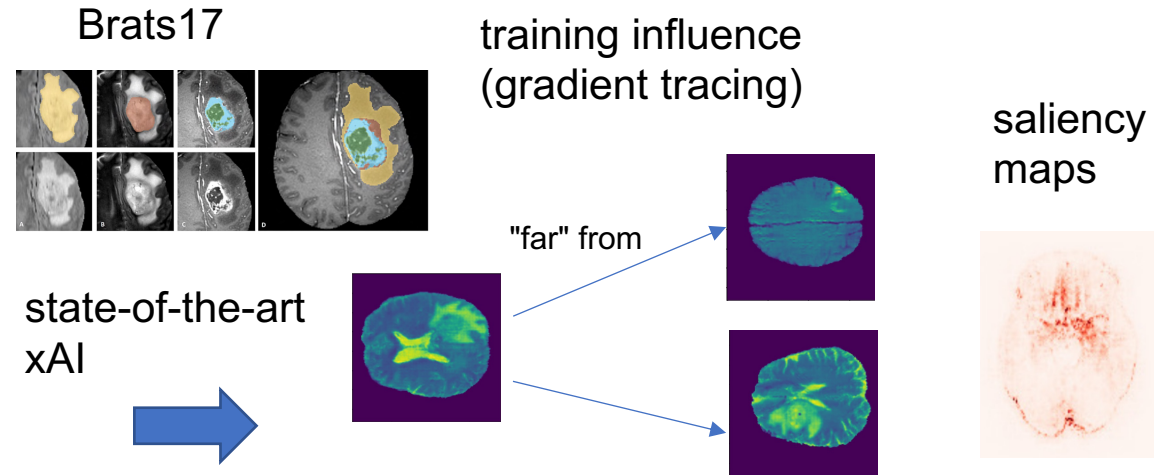
Eur. Phys. J. C 81, 969 (2021)

# Progress Report: MED and NS Use Cases

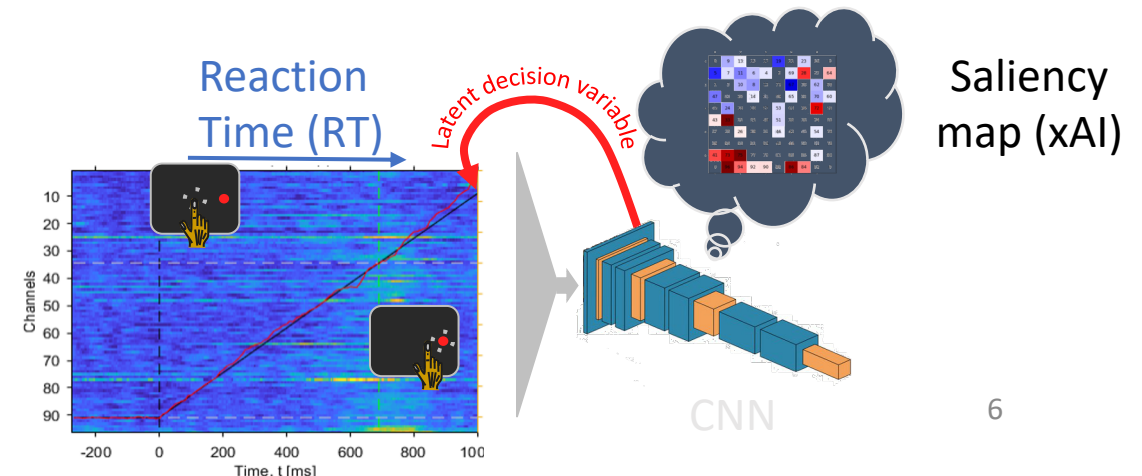
**WP4:** Implemented *AI models for the brain lesion segmentation* in the Brats17 MRI dataset (Unet2D, Resnet 3D). Data augmentation techniques to enhance performances tested. Selected state-of-the-art xAI algorithms, under implementation.



**WP6:** designed and realized a specific CNN (fed by electrophysiological signals) based on a ResNet to uncover an inner decision value increasing in time as a linear ramp eventually allowing to predict at single-trial level the onset timing of overt movements. Test of various xAI algorithms underway



**WP5:** procedure for the realization of the prototypes of the trachea bifurcation (reconstruction of the geometry from the CT scan, numerical code) completed. Study of the GNN model for the simulation of the the air-flow



# Summary and Possible Impact

**Status of the project:** some delay wrt the original plans due to Covid19 restrictions and delay in obtaining funding from one of the funding agency, nevertheless we succeeded in:

- successfully implement appropriate AI algorithms for all the use cases
- perform an extensive survey and analysis of state-of-the art xAI methods by **WP7**
- identify suitable xAI algorithms for the next phase, that now are under implementation

**Expected results:** knowledge base and xAI tools (documentation/procedure/engineering pipelines)

## **Dissemination:**

- scientific publication, conferences
- open access toolkit
- dedicated web site
- hackathons, festivals, challenges...

### **Multiple level impact:**

- 1. enable users to better understand AI models and diagnosis limitation using xAI**
- 2. systematic understanding of which xAI methods better adapts to specific applications**
- 3. skill development and training for young researcher**