

**PHD IN TECHNOLOGIES FOR
FUNDAMENTAL RESEARCH IN PHYSICS AND
ASTROPHYSICS**



Presentation of the Computing curriculum

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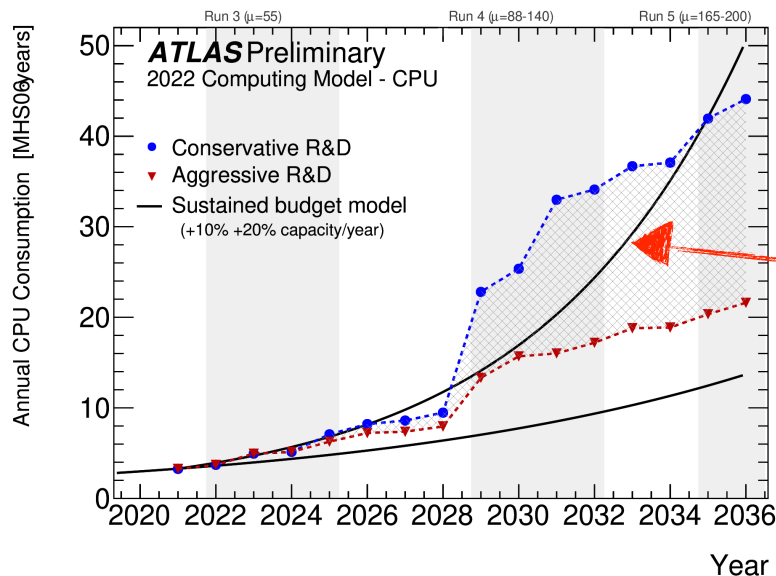
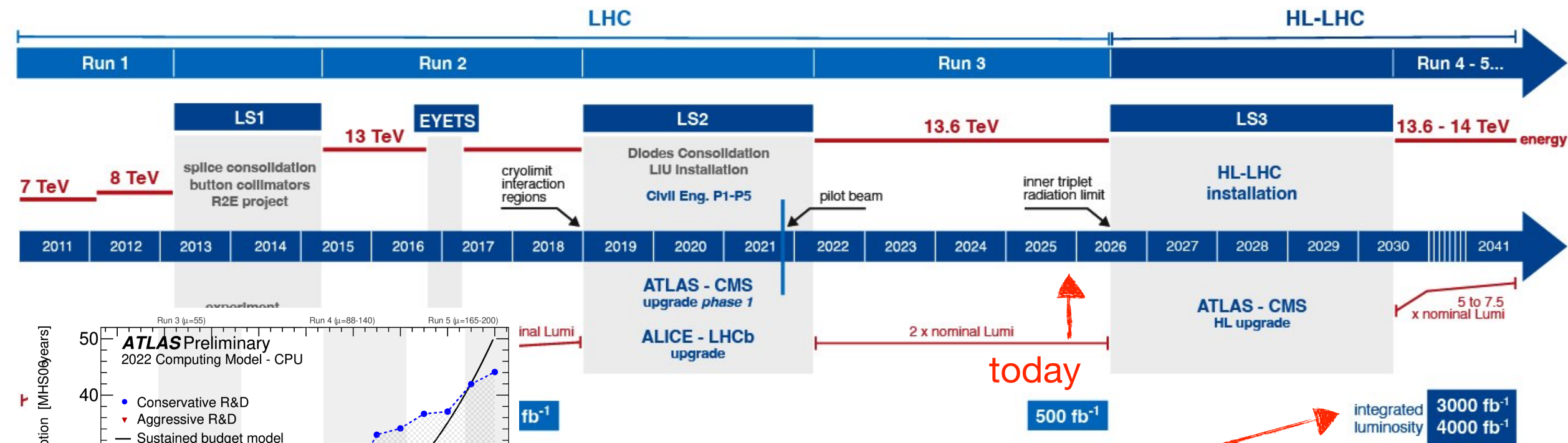
Sapienza Università di Roma and INFN

Welcome meeting - 30.10.2025

Computing and Information Technology Curriculum

- Computing is at the heart of modern fundamental research
- Cutting-edge computational methods crucial in all fields of physics and astrophysics
- Aim of this curriculum is to train experts with advanced computational skills to tackle the most complex challenges in data analysis, modeling, and algorithm development:
 - processing enormous amounts of data (**big data**) from experiments and simulations
 - utilizing **HPC** for complex simulations and advanced data analysis
 - implementing **AI algorithms** for pattern recognition and generative tasks
 - learn efficient **management and storage of scientific data**

Challenge example: big data at HL-LHC



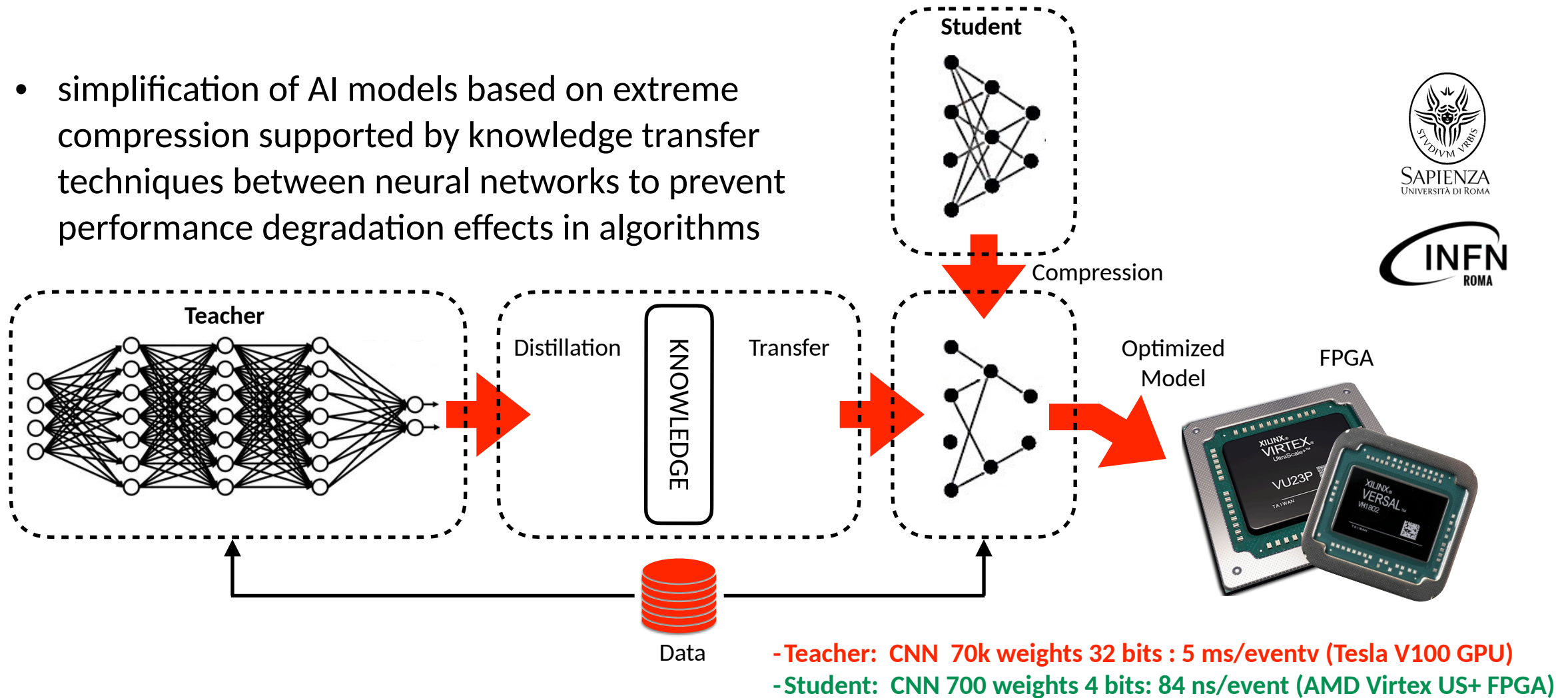
Experimental challenge at the High-Luminosity Large Hadron Collider

example for the ATLAS experiment:

- **computing power needed: x10 wrt today**
- **data volume to be analyzed and stored: ~2.5 exaByte by the end of Run-4 in 2033**

Opportunity example: AI-enhanced Triggers

- simplification of AI models based on extreme compression supported by knowledge transfer techniques between neural networks to prevent performance degradation effects in algorithms



Educational Offer A.Y. 2025/26

- **Advanced scientific programming in Matlab** (Prof. Paolo Bardella; Prof. Stefano Scialò – Politecnico di Torino)
- **Fundamentals of system engineering and project management for large scientific projects** (Dott. Marco Xompero; Dott. Runa Briguglio – INAF Arcetri)
- **Big Data Analysis in Python** (Dott. Gioacchino Vito – INFN – Bari)
- **Programmable System on Chip (SoC) for data acquisition and processing** (Prof. Andrea Fabbri – University of Roma Tre)
- **Adaptive Optics for Astronomy** (Dott. Carmelo Arcidiacono – INAF Padua)
- **Machine Learning for Physics** (Prof. Pierluigi Bortignon – University of Cagliari)
- **Simulation of optical photon propagation for generic scintillator-based detectors** (Dott. Davide Serini – INFN – Bari)

Educational Offer A.Y. 2025/26

- **Cloud Computing & Big Data Lab** (Prof. Tommaso Cucinotta – Sant’Anna School of Advanced Studies)
- **Cloud Computing & Big Data** (Prof. Tommaso Cucinotta – Sant’Anna School of Advanced Studies)
- **Computing Methods for Experimental Physics and Data Analysis** (Prof. Andrea Rizzi; Prof.ssa Alessandra Retico – University of Pisa)
- **Introduction to Neuromorphic Computing** (Prof. Andrea Duggento – University of Roma Tor Vergata)
- **Maximum-entropy methods for complex systems I** (Prof. Diego Garlaschelli – IMT Lucca)
- **Maximum-entropy methods for complex systems II** (Prof. Tiziano Squartini – IMT Lucca)
- **Neural Networks and Deep Learning** (Prof. Giorgio Carlo Buttazzo – Sant’Anna School of Advanced Studies)
- **Quantum Artificial Intelligence** (Prof. Filippo Caruso – University of Florence)

Students of the 41^o cycle

Alessandra Mazzei – *Open BIM and Digital Twin: an integrated digital ecosystem to define a new frontier in Asset Management at the Gran Sasso National Laboratories* – INFN LNGS

Matilde Cavalli - *Research and development of a methodological framework for the prospective assessment of the sustainability of research activities in nuclear physics experiments* – University of Padua

Mattia Maniscalco - *Artificial Intelligence for gamma-ray data analysis: the NASA COSI mission* – INAF Bologna

Mauro Imbrosciano – *Development of Synthetic Tracking algorithms for the rapid detection of Near-Earth Objects (NEOs) using GPU acceleration and Deep Learning techniques* - INAF Catania

Mario Lauriano - *Optimizing Machine Learning Algorithms for High-Precision Photometry and Anomaly Detection in Variable Stars' Light Curves* – INAF Palermo

Miriana Lucchini - *Space Situational Awareness and Characterisation of Resident Space Objects Using Optical Techniques* – Officina Stellare