Welcome to CERN openlab

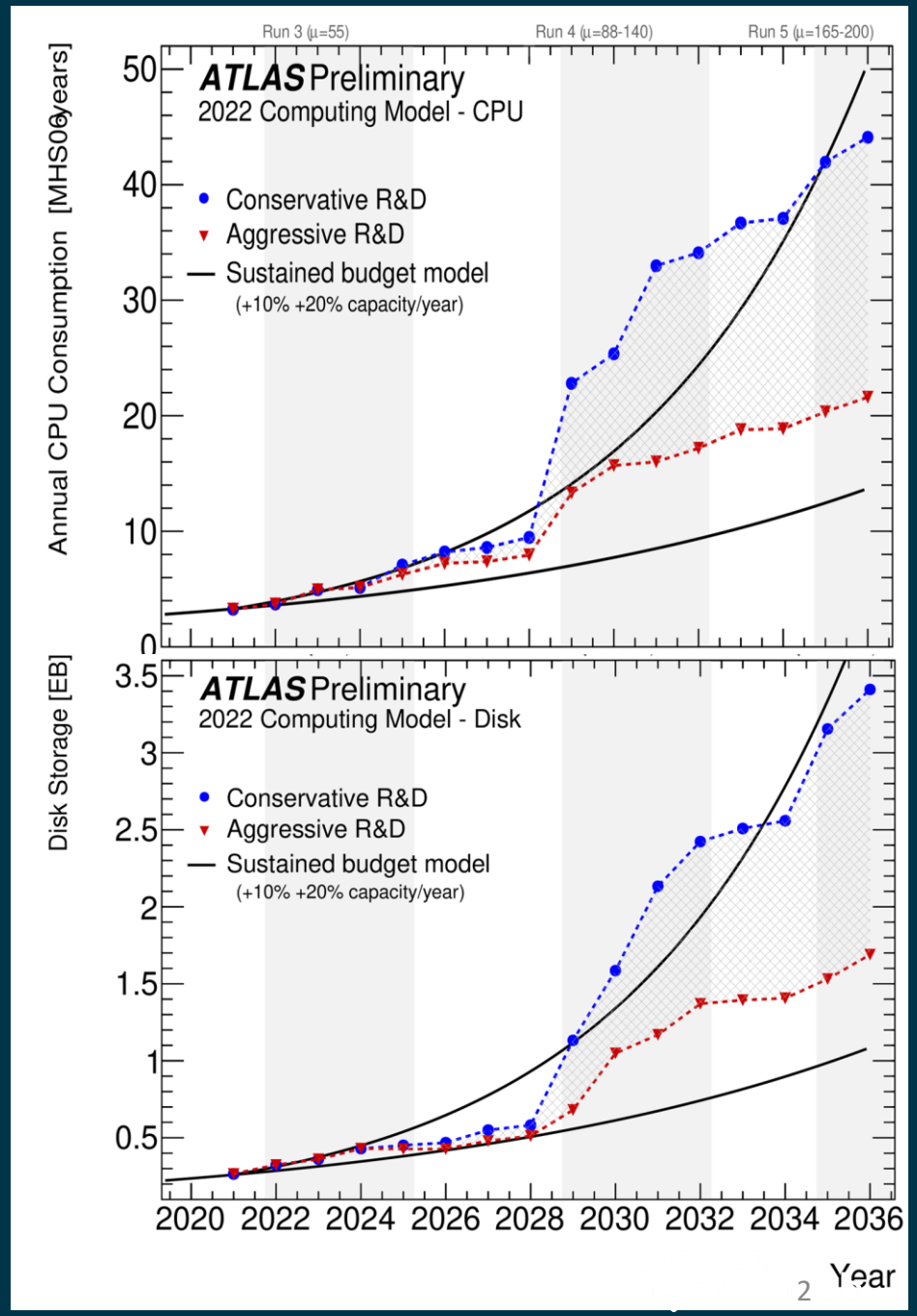
Maria Girone – CERN openlab Head
Matteo Bunino

29/06/2023

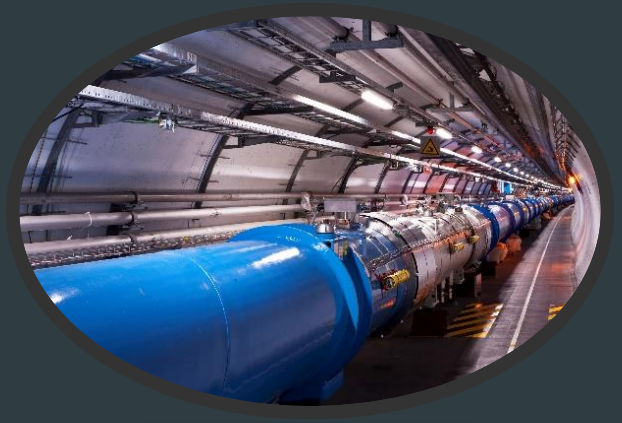
The HL-LHC brings unprecedented computing challenges: the total computing capacity required by the experiments is expected to be 10 times greater than today.

Large investments in R&D are needed to improve software and workflows, reduce storage needs, integrate new resources and solutions from technology providers.

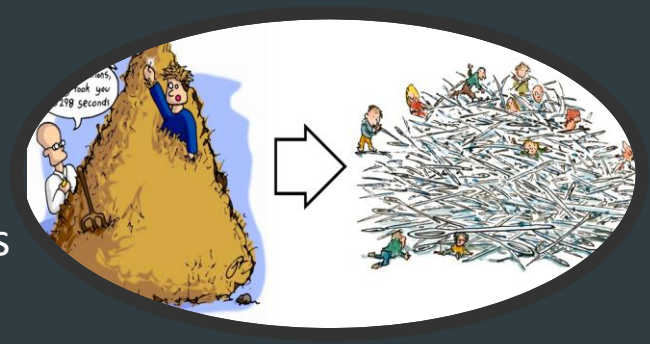
HL-LHC computing needs

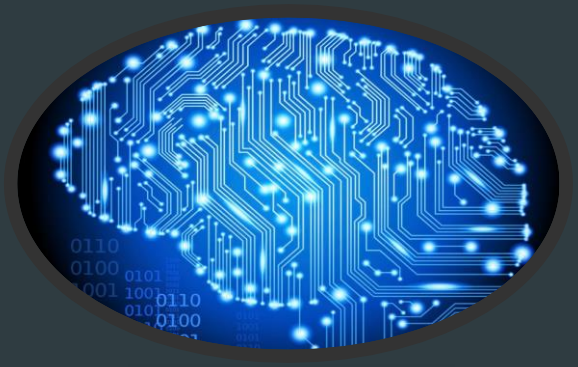


Upgraded Accelerator
- Higher Luminosity



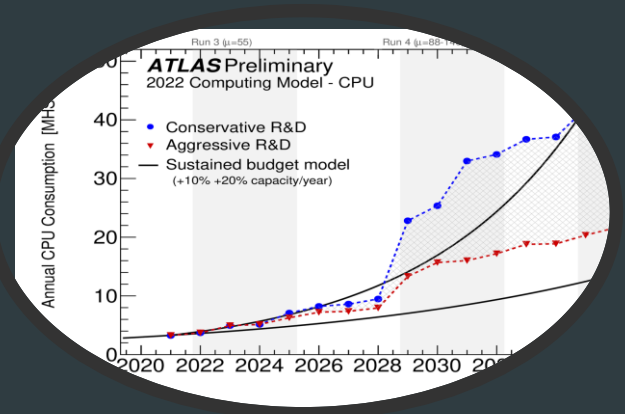
Changing Filtering Paradigms
- Higher Data Rates
- Higher Sensitivity





R&D Investments
- Code modernization, HPC and hardware accelerators
- Reducing storage needs
- New techniques, from AI to QC

Upgraded Detectors
- Higher Granularity
- Higher Occupancy



New Computing Challenges

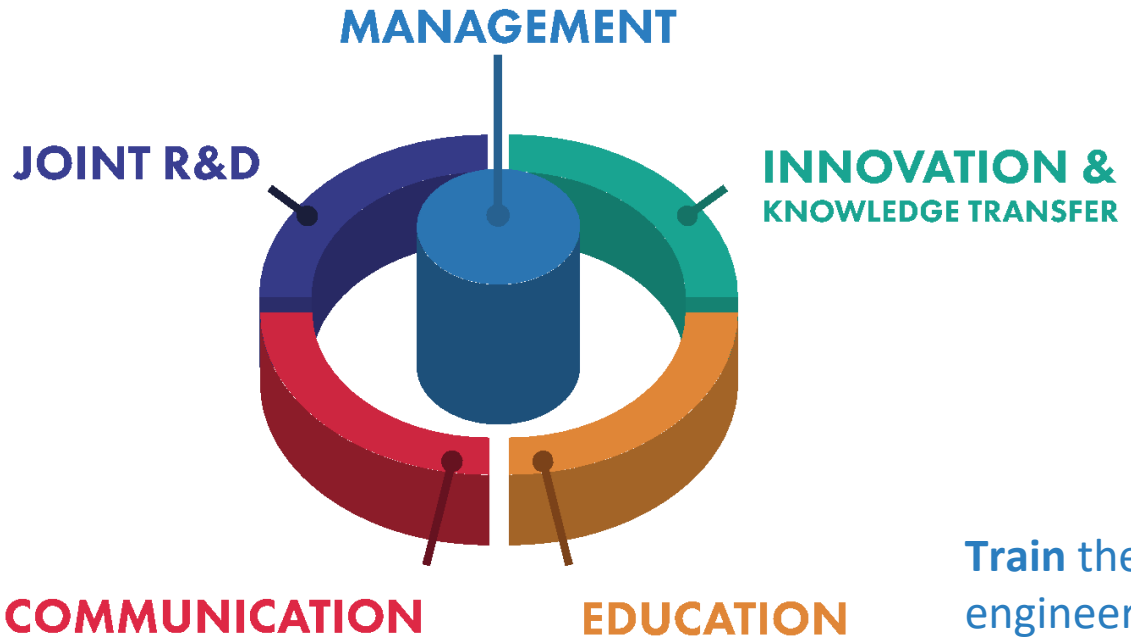
Upgraded program = new challenges

CERN openlab

CERN OPENLAB'S MISSION

Our recipe for success

Evaluate and test state-of-the-art technologies in a challenging environment and improve them in collaboration with industry.

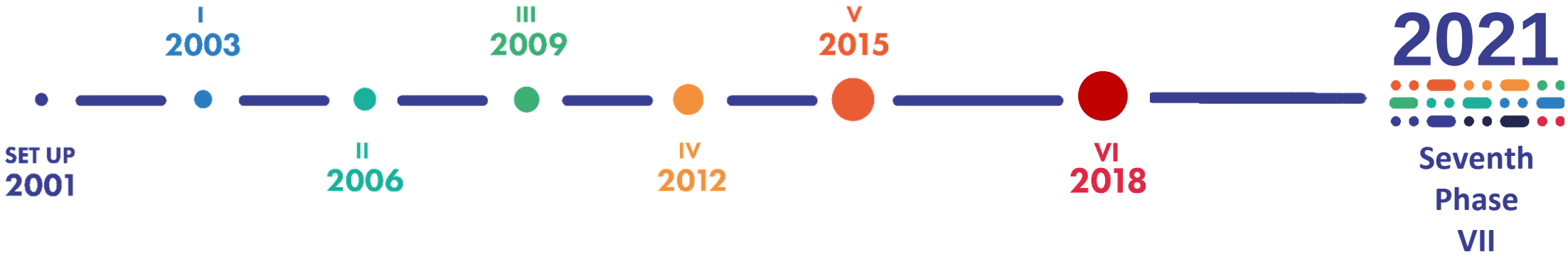


Collaborate and exchange ideas with other communities to create knowledge and innovation.

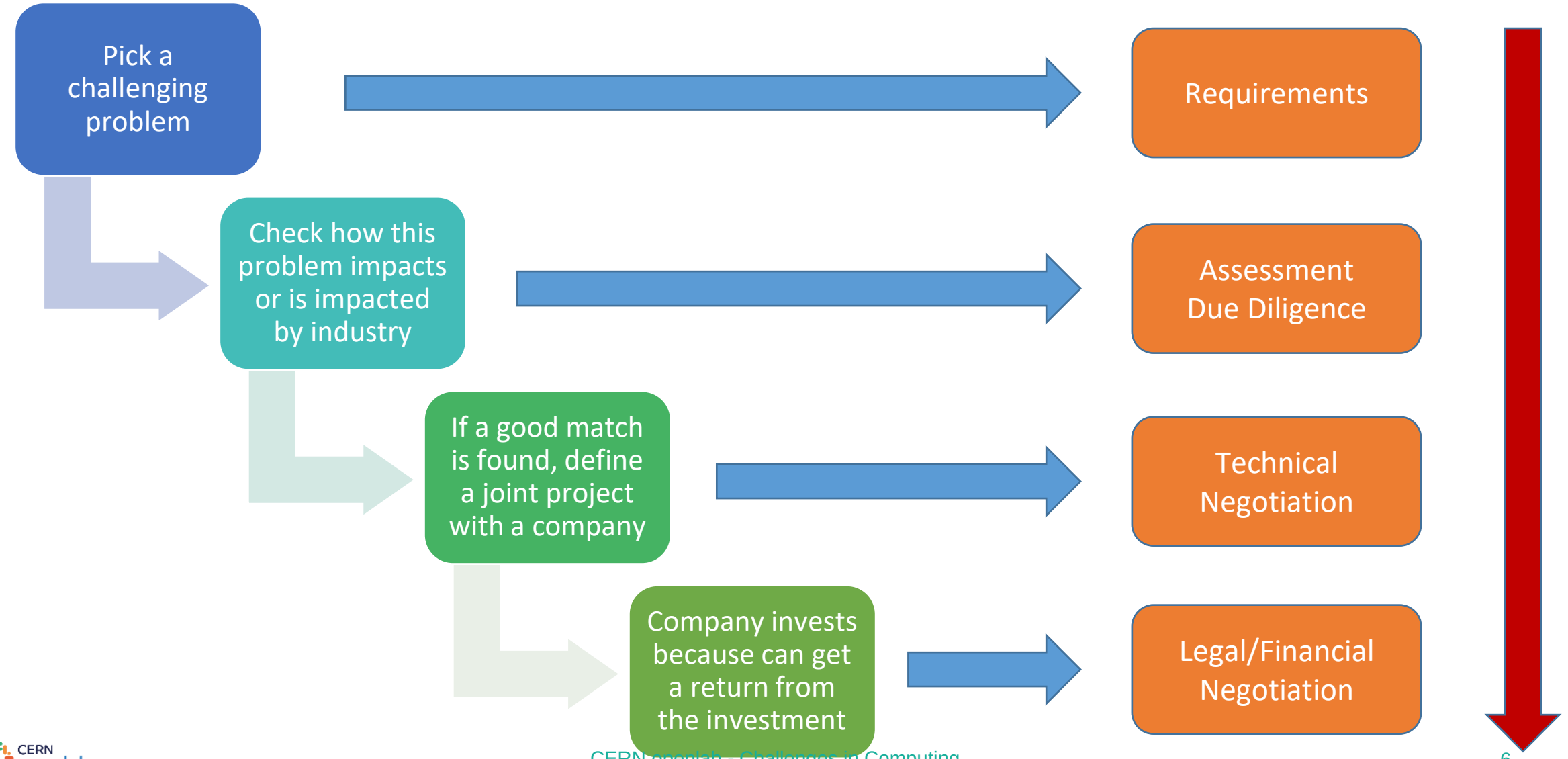
Communicate results, demostrate impact, and reach new audiences.

Train the next generation of engineers/researchers, **promote** education and cultural exchanges.

DRIVING INNOVATION FOR 20 YEARS



Collaboration Model



Collaboration members

PARTNERS

intel

ORACLE

SIEMENS

Micron

CONTRIBUTORS

IBM

E4 COMPUTER ENGINEERING

Comtrade Three-Sixty

Google

Roche

RESEARCH

INFN Istituto Nazionale di Fisica Nucleare

Fermilab

SCIMPULSE

UNIVERSITAS STUDIORUM TERGESTINA MCMXXIV

Strategic Innovation Areas

CERN openlab

XT
eXascale Technologies

A comprehensive investigation of HPC and Cloud infrastructures, frameworks, tools to support key scientific workloads and applications, including AI, HPC, Digital Twins

AI-S
Artificial Intelligence for Science

Analysis and development of algorithms, optimisation for new architectures, interpretability, synergies between Physics and other sciences

QTI-C
Quantum Technology Initiative - Computing

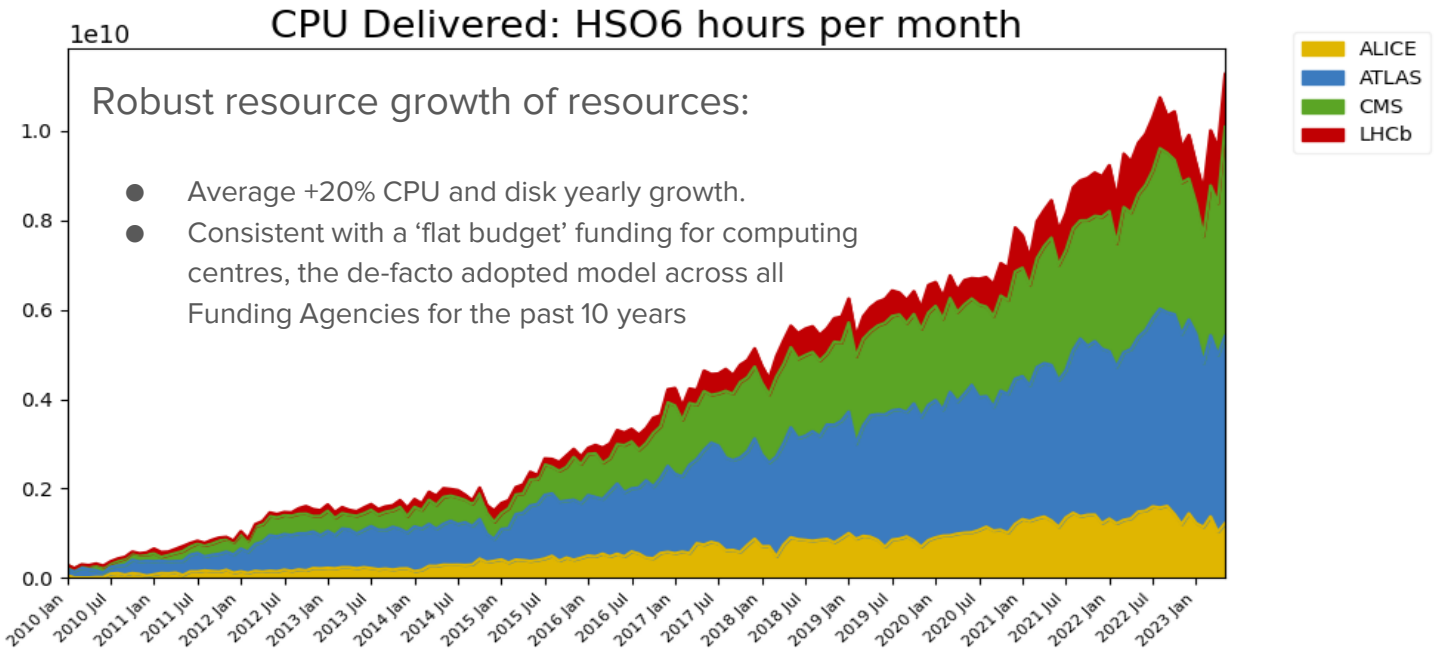
Assess the potential impact of quantum computing in HEP and other sciences, investigate quantum machine learning algorithms and areas of potential quantum advantage, set up a collaborative quantum computing (simulation) platform

MSC
Multi-Science Collaborations

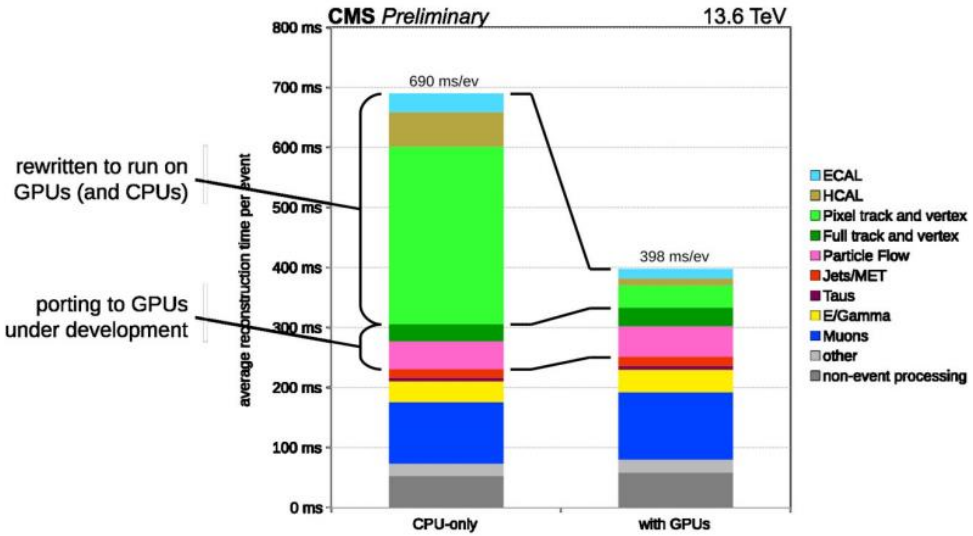
Share the expertise and knowledge generated across all activities with other sciences, work with CERN KT to explore novel applications of CERN computing systems and ideas, create collaborations and contribute to common solutions

Exascale technologies: Heterogeneous Architectures Adoption

We collaborate with Intel, E4/NVIDIA, and Micron



WLCG resources: compute. Image courtesy of Alessandro Di Girolamo et al.



Run 3 – more than 40% online reconstruction offloaded to GPU.
Image courtesy of Andrea Bocci et al.

Exascale technologies: Heterogeneous Architectures Adoption

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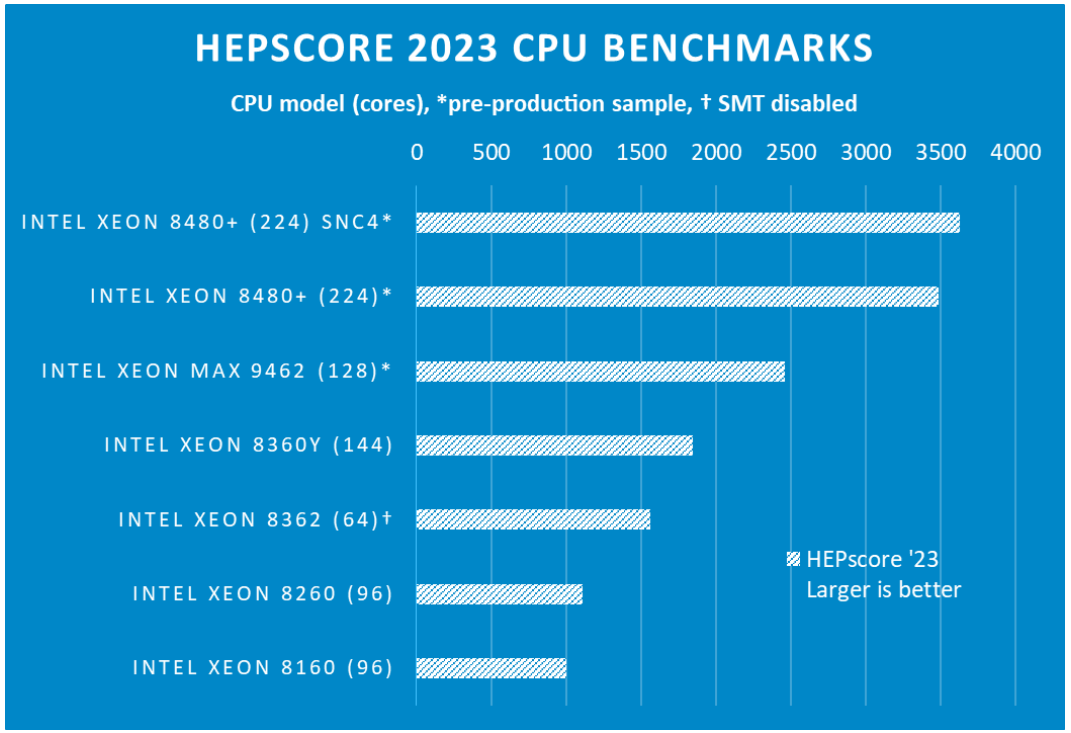
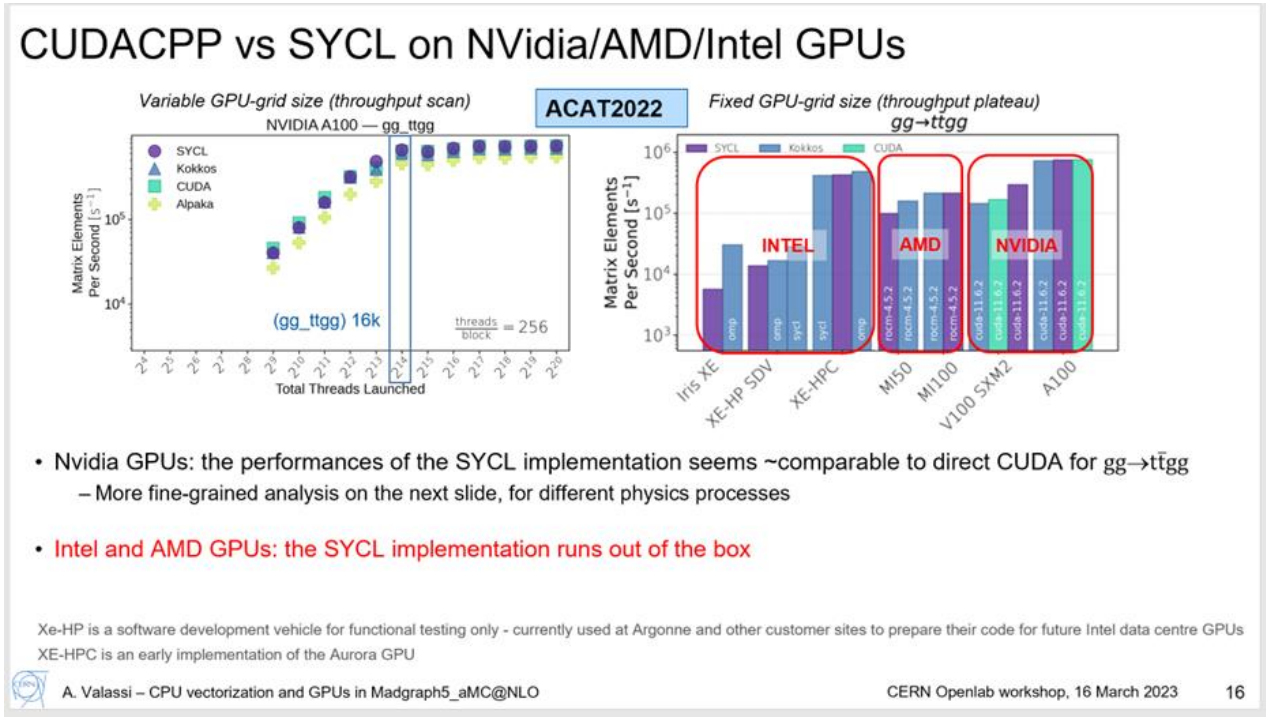
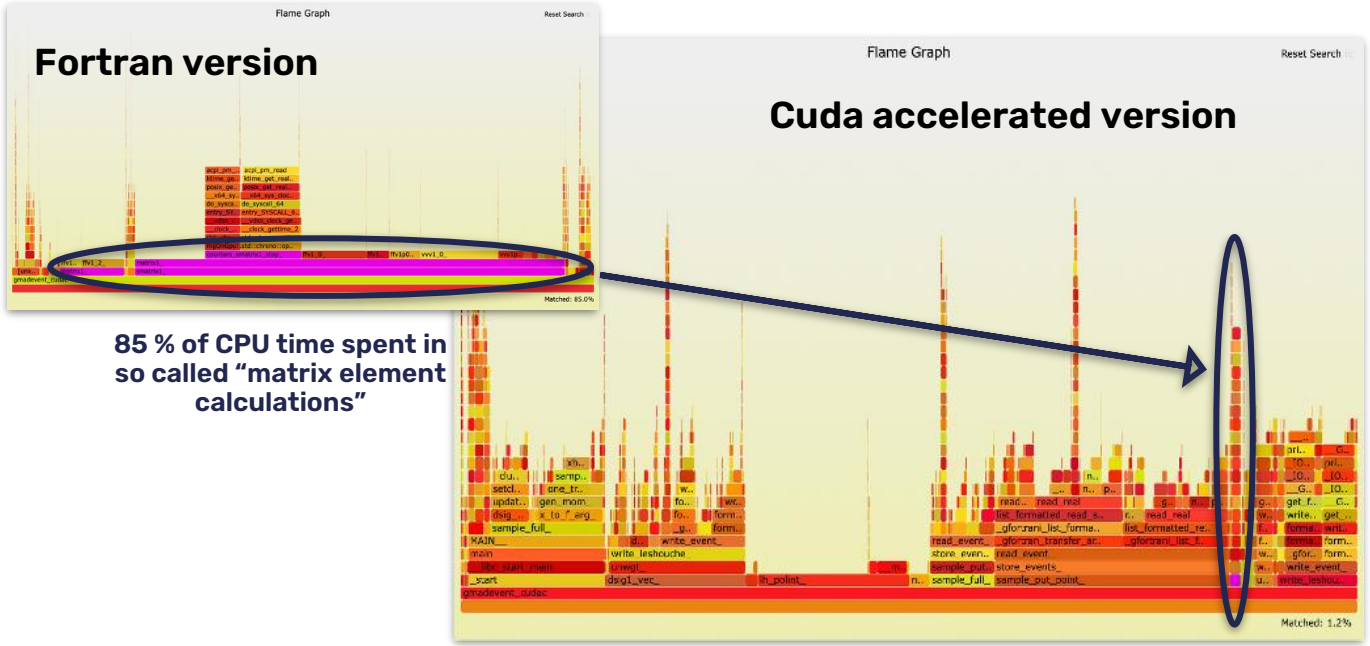


CPU Benchmarking. Image courtesy of David Southwick et al.



GPU Benchmarking. Image courtesy of Andrea Valassi et al.

Exascale technologies: Heterogeneous Architectures Adoption (2)



85 % of CPU time spent in so called “matrix element calculations”

Madgraph5_aMC@NLO speedup on NVidia GPUs for fast MCMC simulations.

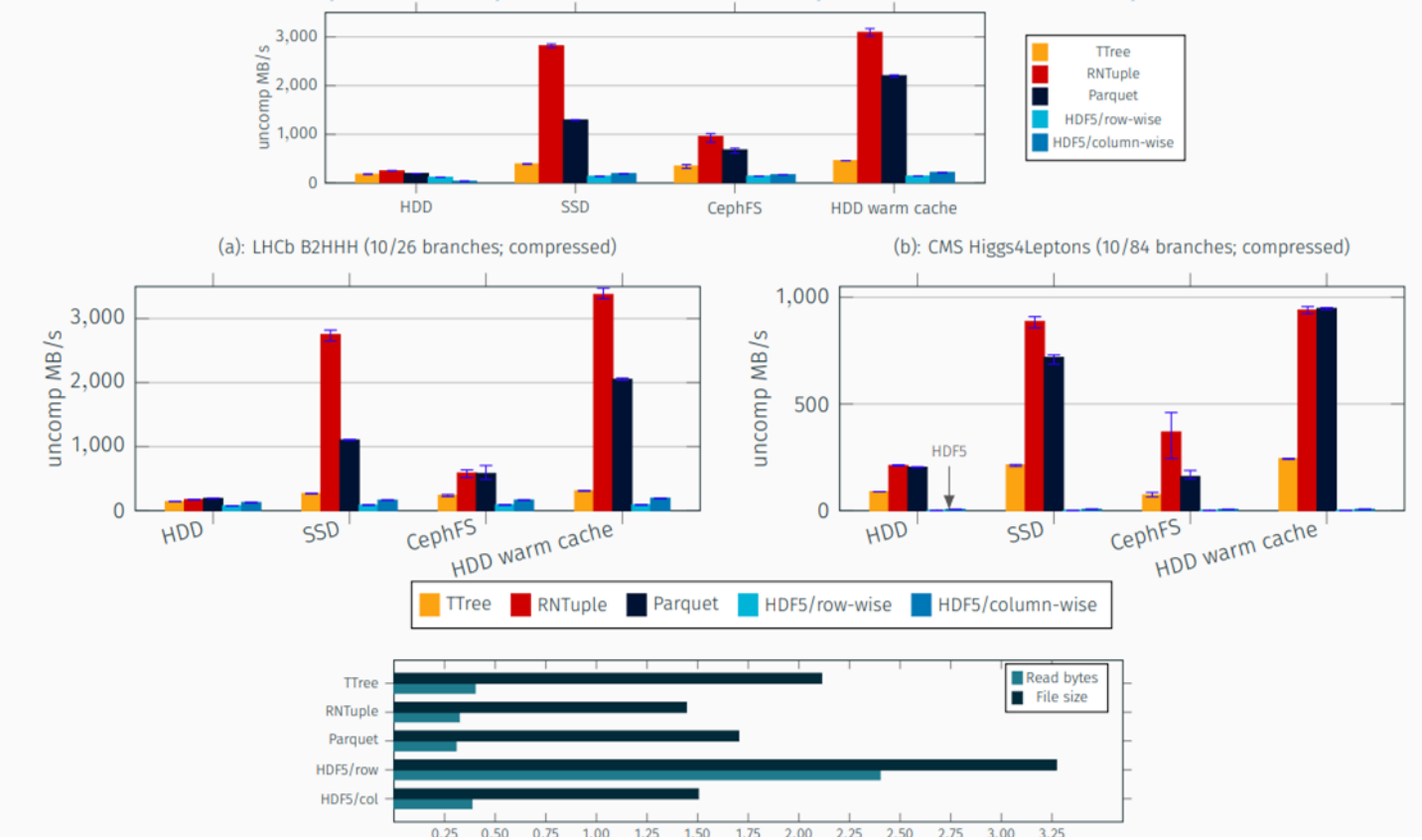
Relevant lectures:

GPU programming
Stephan Hageboeck
IT Amphitheatre (31/3-004)
14:00-16:00, 1 August

Best practices: the theoretical and practical underpinnings of writing code that is less bad
Axel Naumann
IT Amphitheatre (31/3-004)
14:00-15:30, 3 August

Exascale Technologies: Advanced Data and Storage Solutions

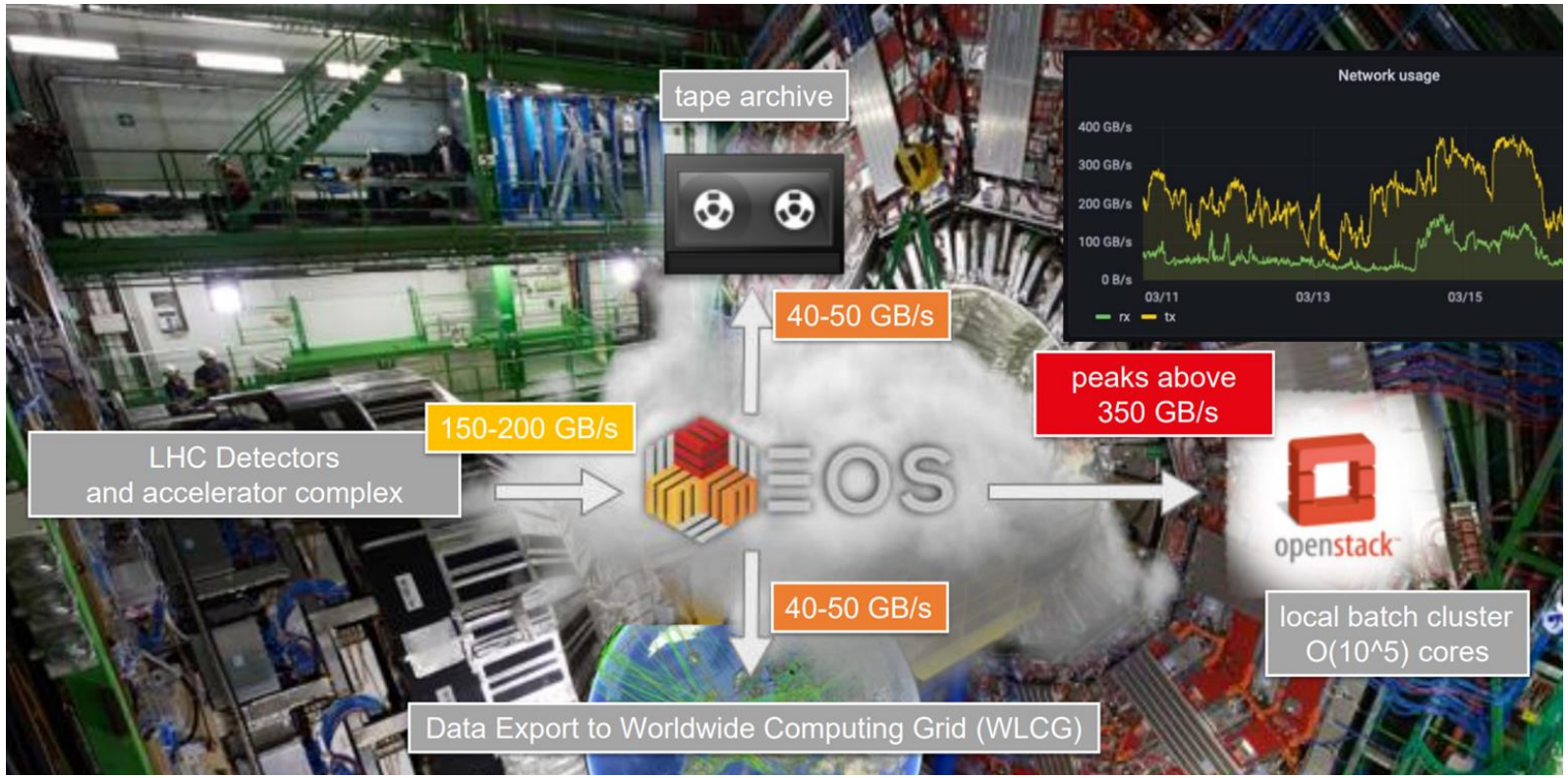
We collaborate with Intel, HPE, SIEMENS, Comtrade, and ORACLE.



ROOT's RNTuple State of Affairs: Throughput and Size. Image courtesy of Javier López-Gómez et al.

Exascale Technologies: Advanced Data and Storage Solutions (2)

We collaborate with Siemens, Comtrade, and Oracle.



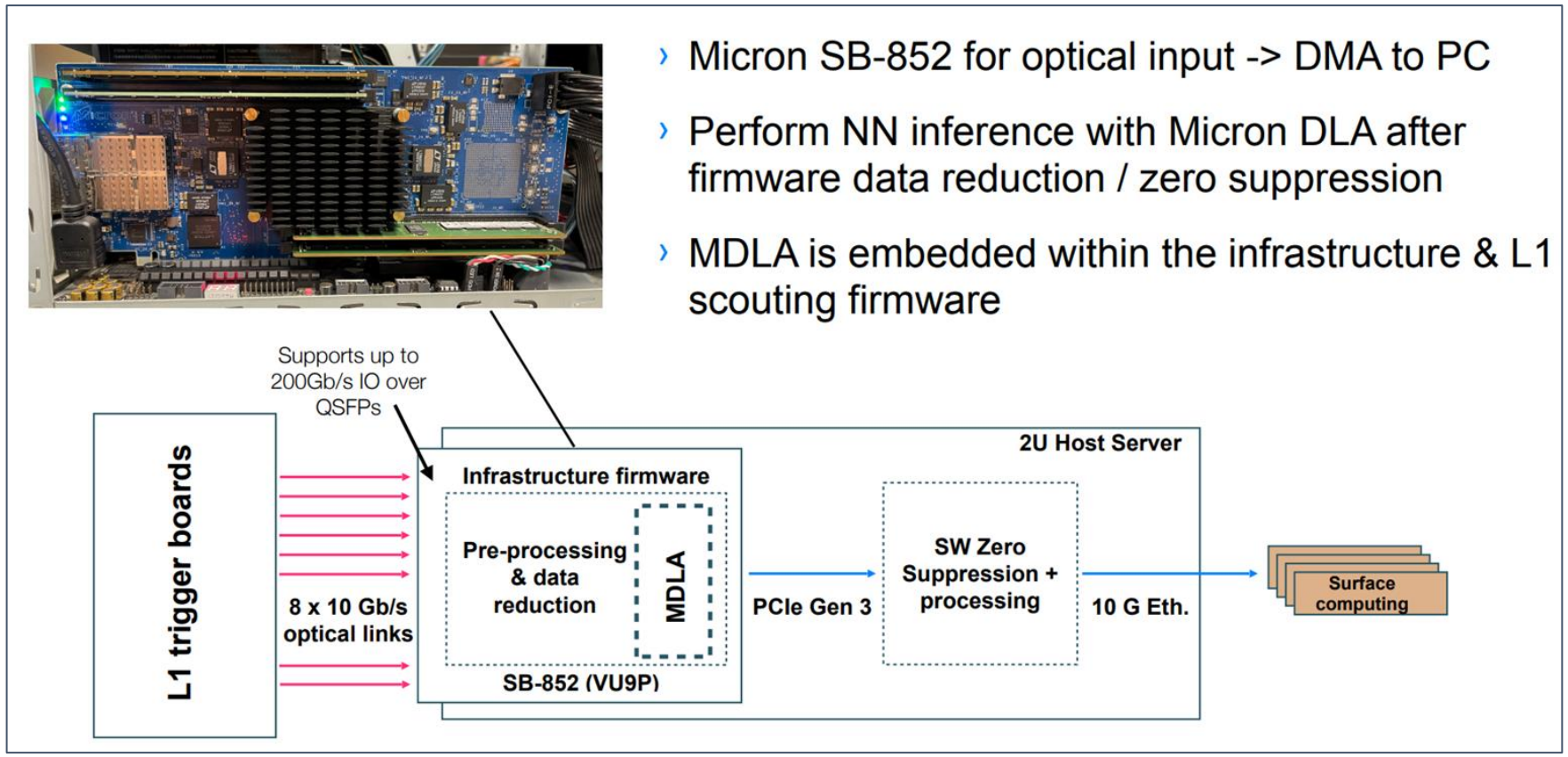
Physics data recording with EOS. Image courtesy of Luca Mascetti et al.

Relevant lectures:

Highly durable and dense data storage through synthetic DNA
Raja Appuswamy
IT Amphitheatre (31/3-004)
14:00-16:00, 8 August

Exascale technologies: AI and HPC

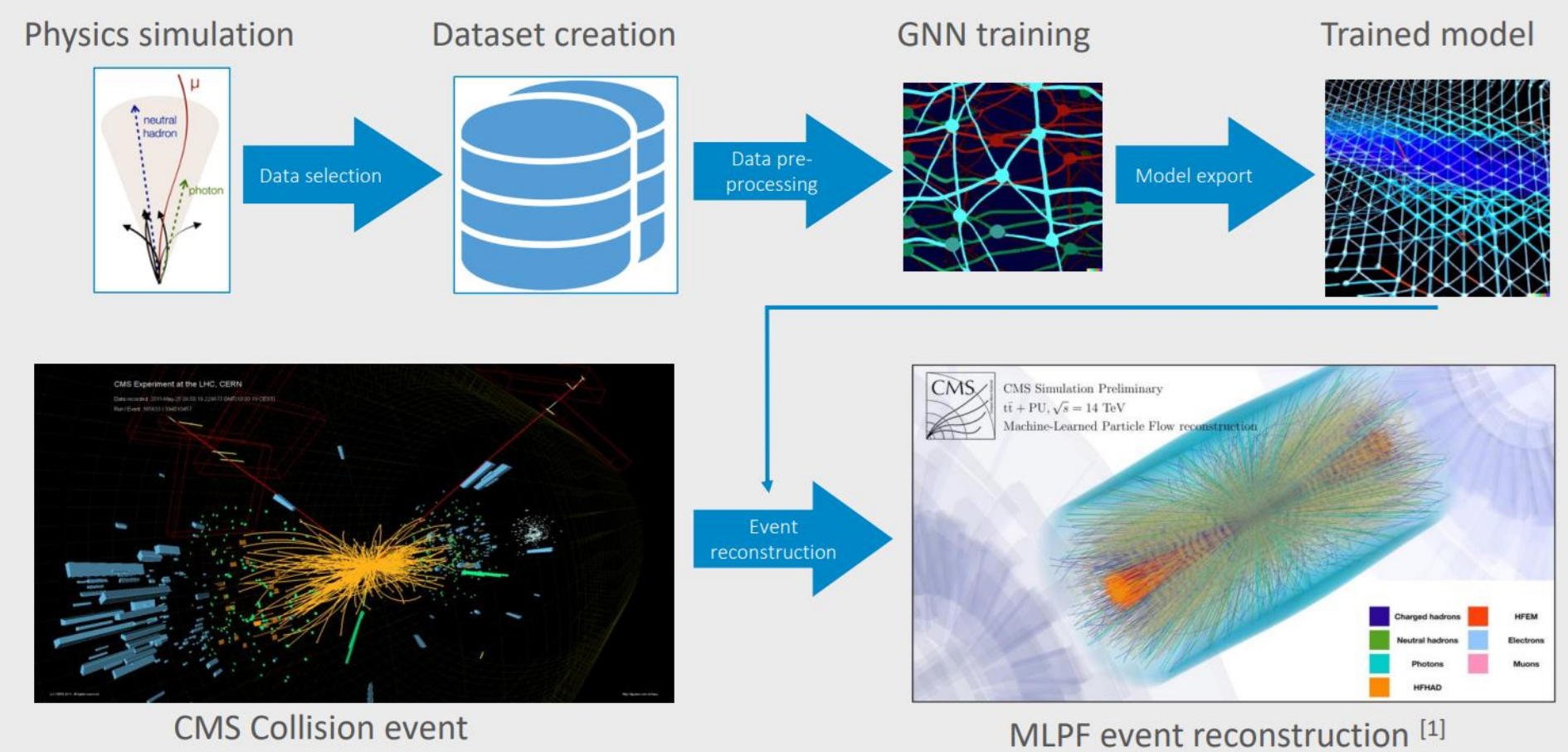
We collaborate with Micron, E4/NVIDIA, and ORACLE.



Deep learning-based trigger embedded on Micron's board. Image courtesy of Thomas James et al.

Exascale technologies: AI and HPC (2)

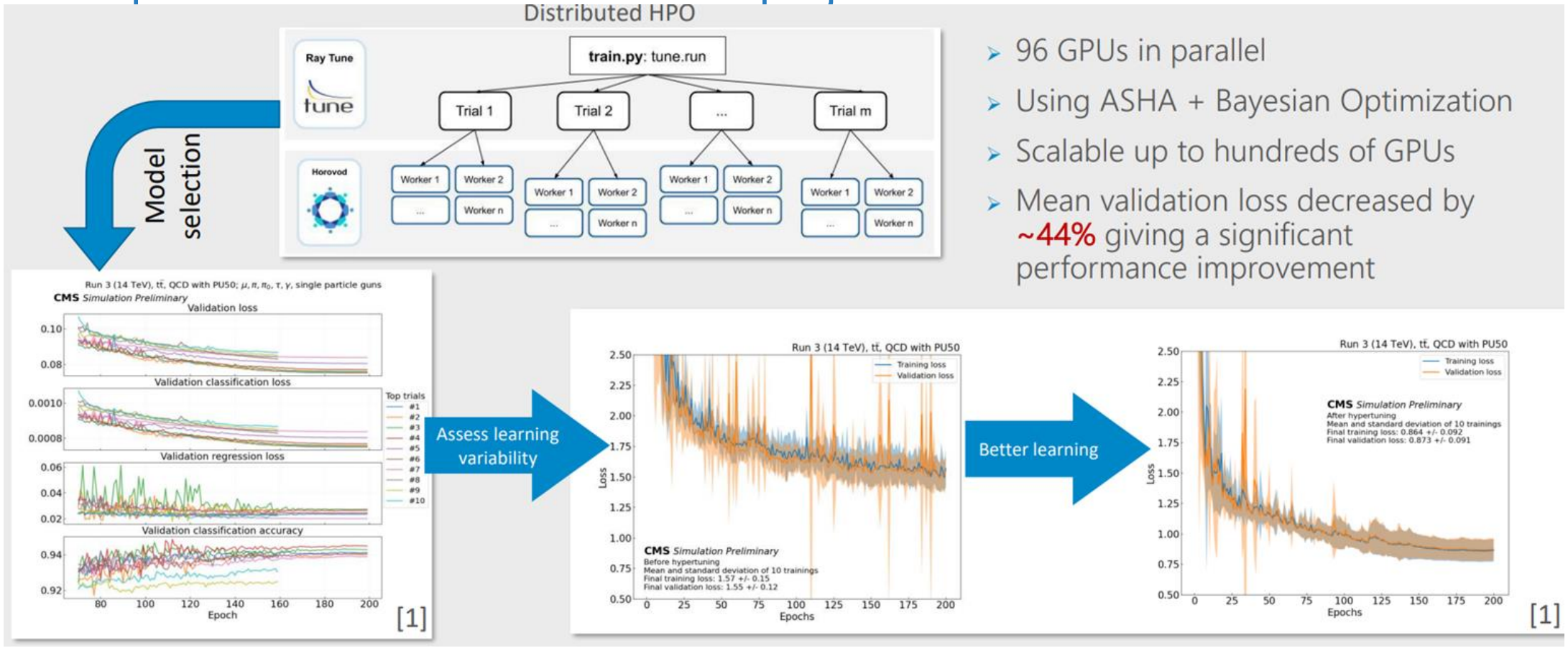
We take part to EC-funded CoE RAISE project



AI-based particle flow reconstruction workflow. Image courtesy of Eric Wulff et al.

Exascale technologies: AI and HPC (3)

We take part to EC-funded CoE RAISE project



Large-scale distributed hyperparameter optimization (HPO). Image courtesy of Eric Wulff et al.

Exascale technologies: AI and HPC (3)

Proposed lectures

Introduction to Machine Learning and Deep Learning
Michael Kagan
IT Amphitheatre (31/3-004)
14:00-16:30, 13 July

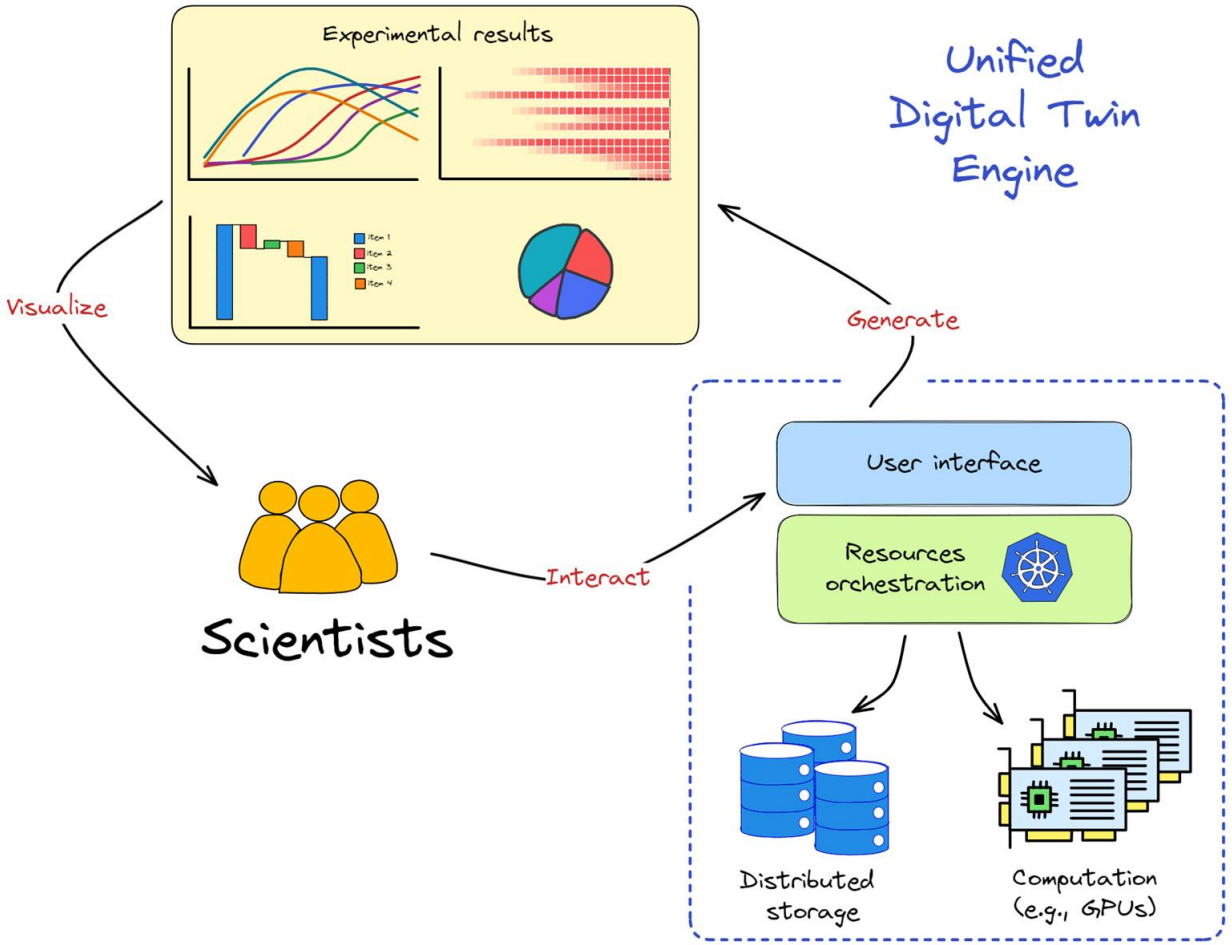
Graph Neural Networks: From fundamentals to Physics application
Ilias Tsaklidis
IT Amphitheatre (31/3-004)
14:00-16:00, 17 July

Hyperparameter Optimization for Deep Learning Models Using High Performance Computing
Eric Wulff
IT Amphitheatre (31/3-004)
14:00-16:00, 18 July

Reinforcement learning and its applications at CERN
Matteo Bunino
IT Amphitheatre (31/3-004)
14:00-15:30, 21 July

Digital Twins

We participate to EC project **interTwin**, and ECMWF's EMPP.



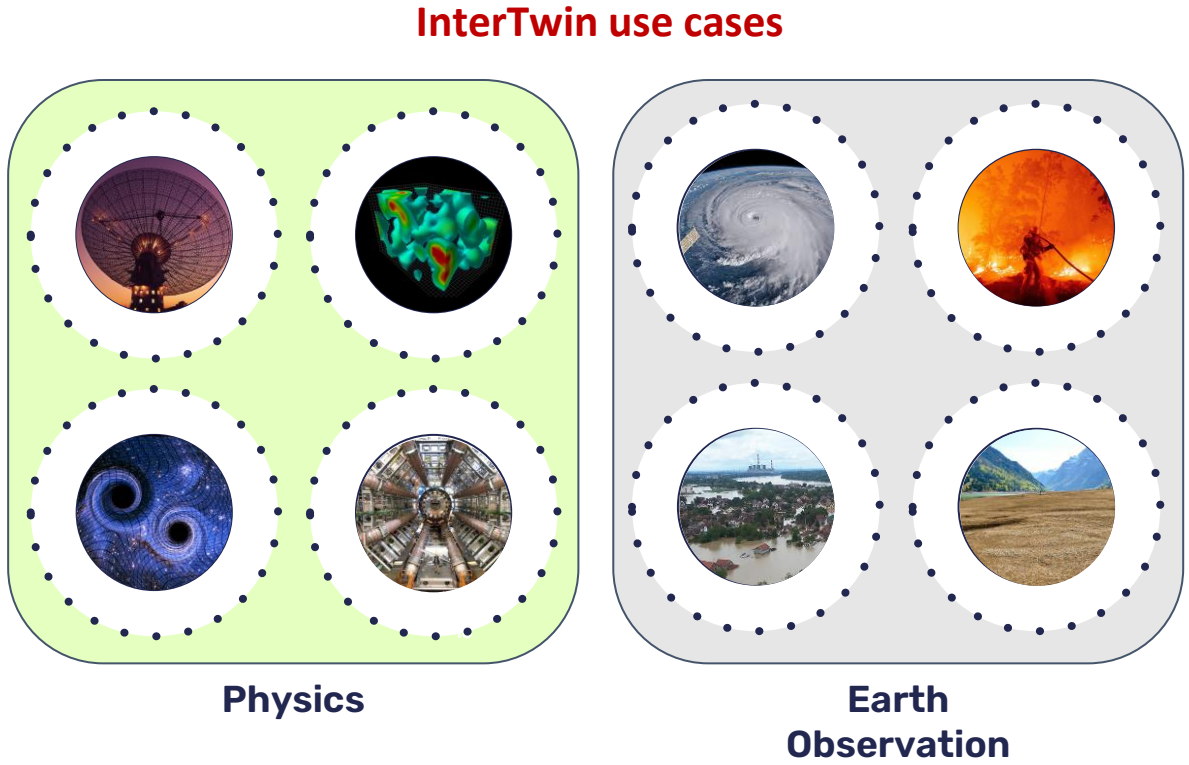


Image courtesy of Alexander Zoechbauer et al.

Digital Twins (2)

We participate to EC project interTwin, and **ECMWF's EMPP**.

First proof-of-concept of a machine-learning based global environmental model trained on terabytes of observational data

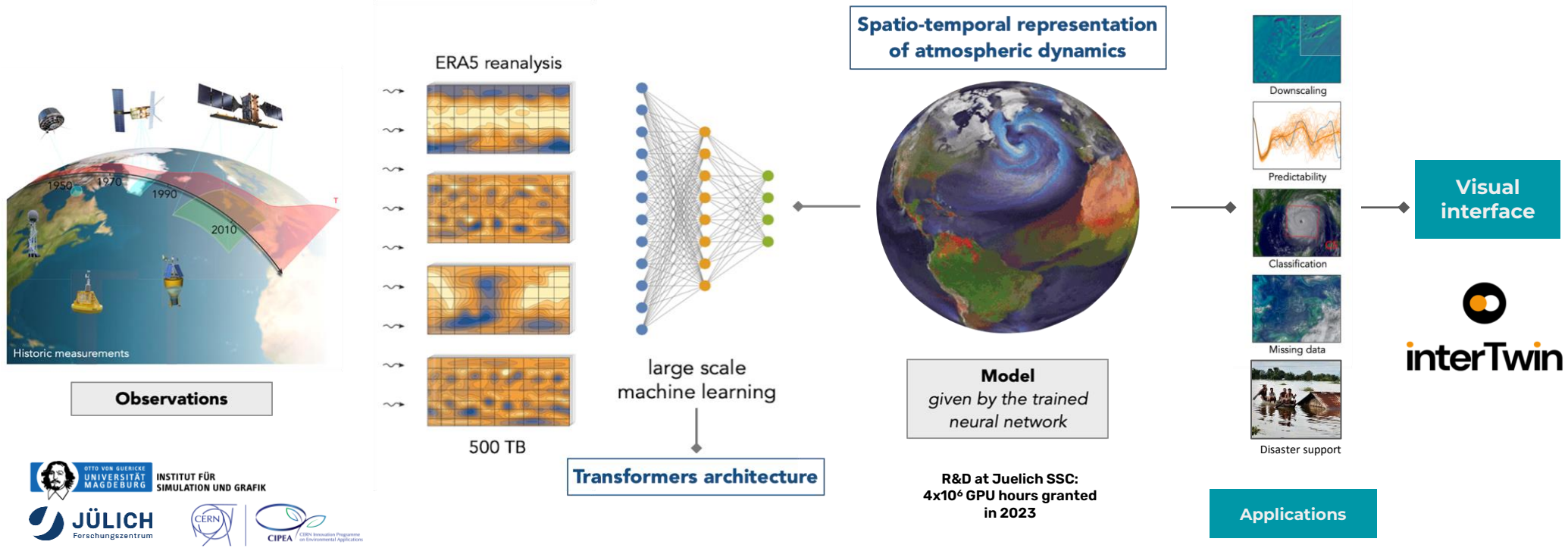


Image courtesy of Ilaria Luise et al.

Digital Twins (3)

Proposed lectures

Digital twins and their application at CERN
Ilaria Luise, Alexander Zoechbauer, Kalliopi Tsolaki
IT Amphitheatre (31/3-004)
14:00-16:00, 7 August

Agent-Based Modeling: A Paradigm for Simulating Complex Systems
Lukas Breitwieser, Tobias Duswald
IT Amphitheatre (31/3-004)
14:00-16:00, 19 July

Quantum computing

Proposed lectures

Basics of quantum computing (theory)
Alice Barthe
BE Auditorium Meyrin (6/2-024)
14:00-15:30, 27 July

Basics of quantum computing (practice)
Su Yeon Chang
BE Auditorium Meyrin (6/2-024)
15:30-17:00, 27 July

Applications of Quantum Computing: CERN use case, Quantum Machine Learning and optimization
Carla Sophie Rieger
IT Amphitheatre (31/3-004)
14:00-15:30, 31 July

Quantum Kernel Methods (hands-on on Quask)
Francesco Di Marcantonio, Roman Wixinger
IT Amphitheatre (31/3-004)
15:30-16:00, 31 July

Evening lectures

Introduction to quantum computing (1/2)
Ahmed Abdelmotteleb
IT Amphitheatre (31/3-004)
17:00-18:30, 25 July

Introduction to quantum computing (2/2)
Ahmed Abdelmotteleb
IT Amphitheatre (31/3-004)
17:00-18:30, 26 July

Movie night: "Particle Fever"
Mark Levinson
Main Auditorium (500/1-001)
19:30-22:00, 25 July

Thanks!