

Present and Future Challenges facing High Energy Physics

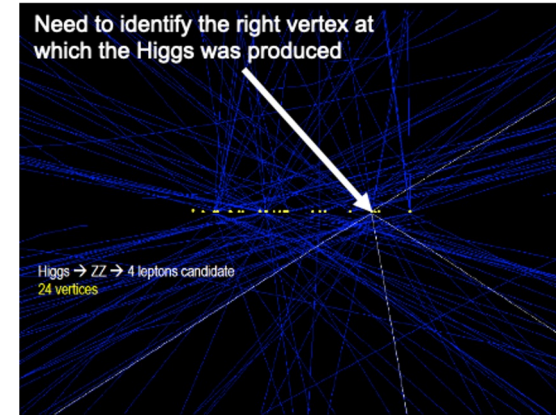
Maria Girone, CERN

Data Volume and Data Complexity

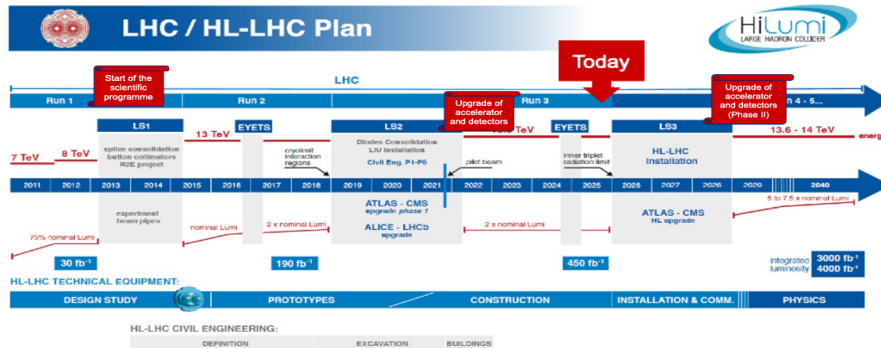
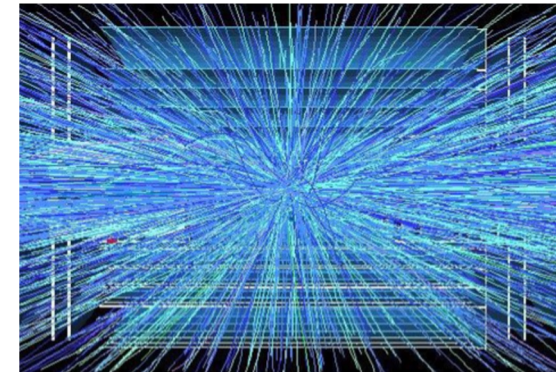
HEP Discovery physics is at the intensity frontier

- To probe incredibly rare processes we must produce more events
 - Increases our reach but makes the data much more complex
- High Energy Physics is preparing for the HL-LHC program in 2029
 - Each experiment will collect exabytes of data annually

2018: 20-40 collisions per crossing



2029: 150-200 collisions per crossing



Data Processing and Data Distribution

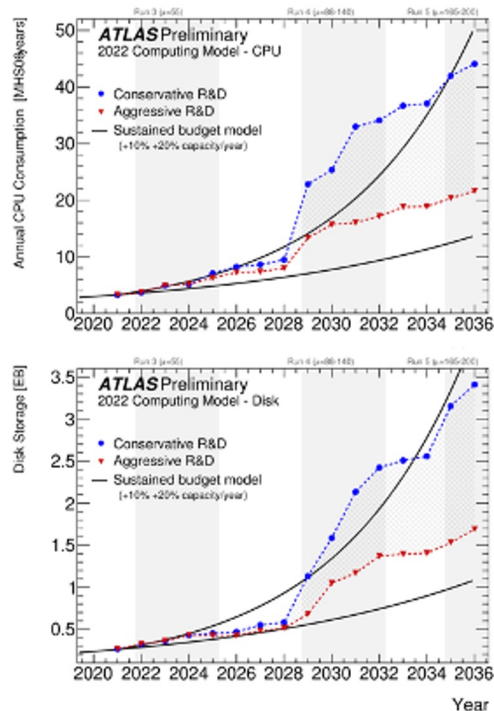
Significant investments and progress in computing R&D to face

To process exabytes for we moving to exascale computing

- Investigating accelerated processors like GPUs and FPGAs
- Techniques like AI/ML to more efficiently process and analyze data
- New resources like HPC and Clouds
- Forward looking disruptive technologies like Quantum Computing

The data is collected at the accelerator but is analyzed by globally distributed collaborations of thousands of scientists using hundreds of processing sites

- Investments in advanced storage and data distribution solutions



Computing Strategy

From the European Strategy for Particle Physics 2020 Update:

“The community must vigorously pursue common, coordinated R&D efforts in collaboration with other fields of science and industry, to develop software and computing infrastructures that exploit recent advances in information technology and data science. “

To meet the challenges the HEP community must carry out planned and coordinated R&D programmes

- Involvement in the planning stage of future multidisciplinary research infrastructures in order to ensure that these systems will be best equipped to address the needs of the community
- Tools and applications development for effective use of capacity provided by heterogeneous hardware and specialized architectures such as GPUs, FPGAs, and TPUs.
- Improvements to the techniques like AI/ML, software algorithms and the data formats to allow for more efficient processing and storage.
- Application and data access tools development at HPC facilities and using commercial Clouds, which can deliver extra capacity to particle physics.
- Preparation and follow-up for the innovative, new technologies on the horizon, such as quantum computing and neuromorphic computing

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“The community must vigorously pursue common, coordinated R&D efforts in collaboration with other fields of science and industry, to develop software and computing infrastructures that exploit recent advances in information technology and data science. “

“Synergies between particle and astroparticle physics should be strengthened through scientific exchanges and technological cooperation in areas of common interest and mutual benefit.”

To meet the challenges the particle physics community must carry out carefully planned and coordinated R&D programmes

- Tools and applications development for effective use of capacity provided by heterogeneous hardware and specialized architectures.
- Improvements to the software and the data formats to allow for more efficient processing and storage.
- Application and data access tools development at HPC facilities and using commercial Clouds, which can deliver extra capacity to particle physics.
- Continued R&D on data organization, infrastructure, management and access in the face of technological changes and cost increase due to large data volume, data preservation and the data open-access requirement
- Preparation and follow-up for the innovative, new technologies on the horizon, such as quantum computing and neuromorphic computing