Quantum Computing for High Energy Physics Workshop

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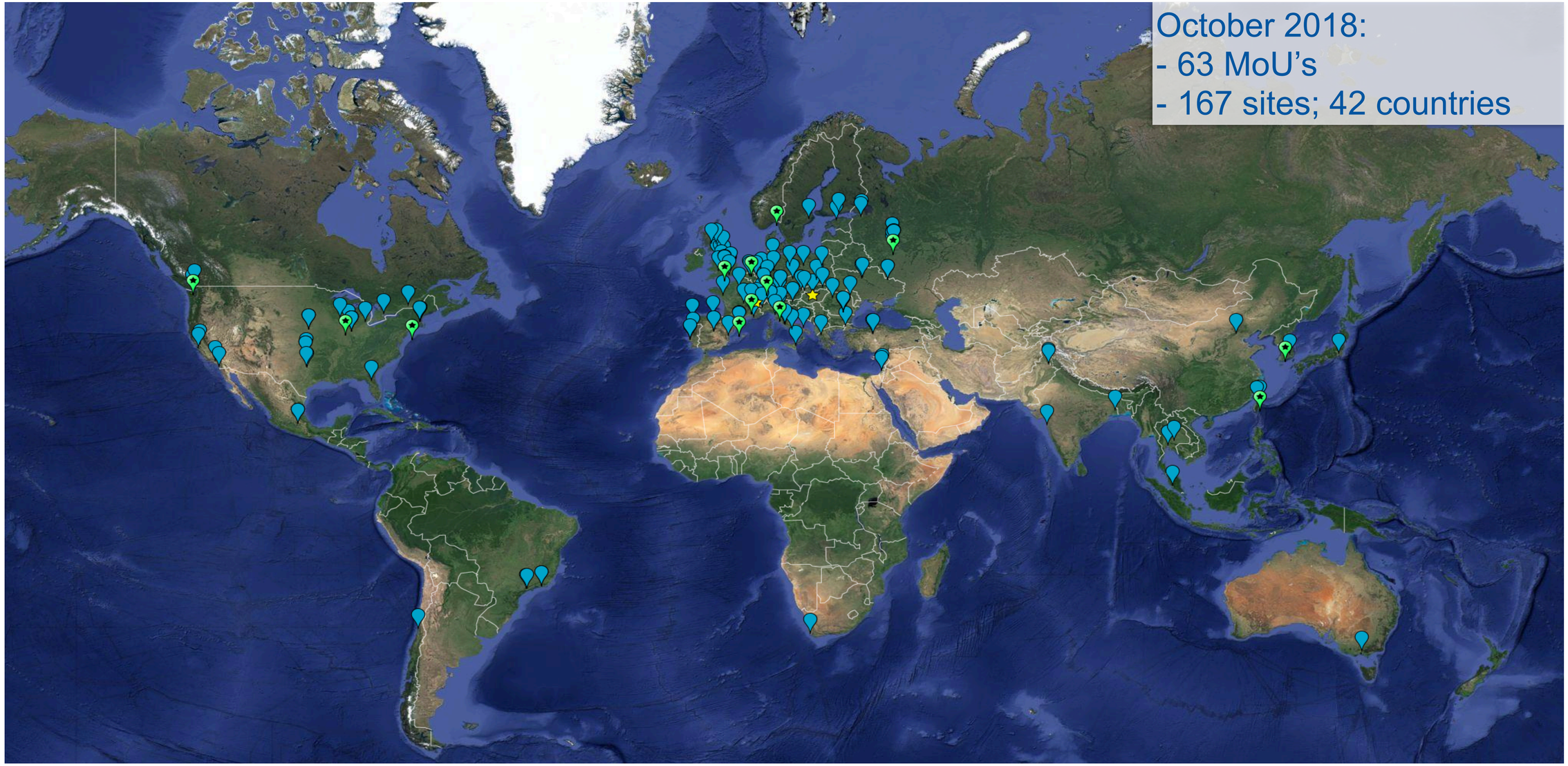
Welcome and
brief Introduction

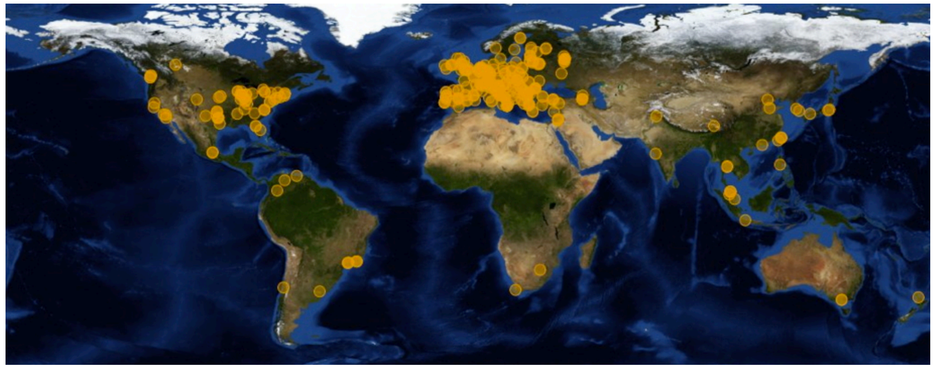
WLCG Collaboration

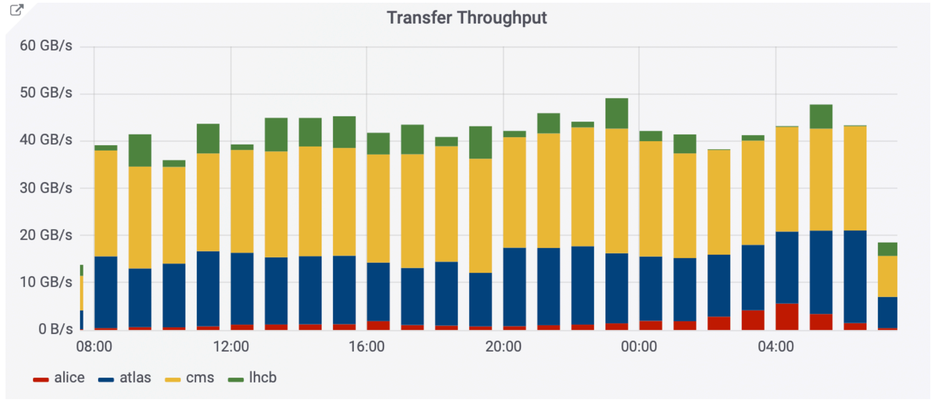


Characterisation of HEP Computing

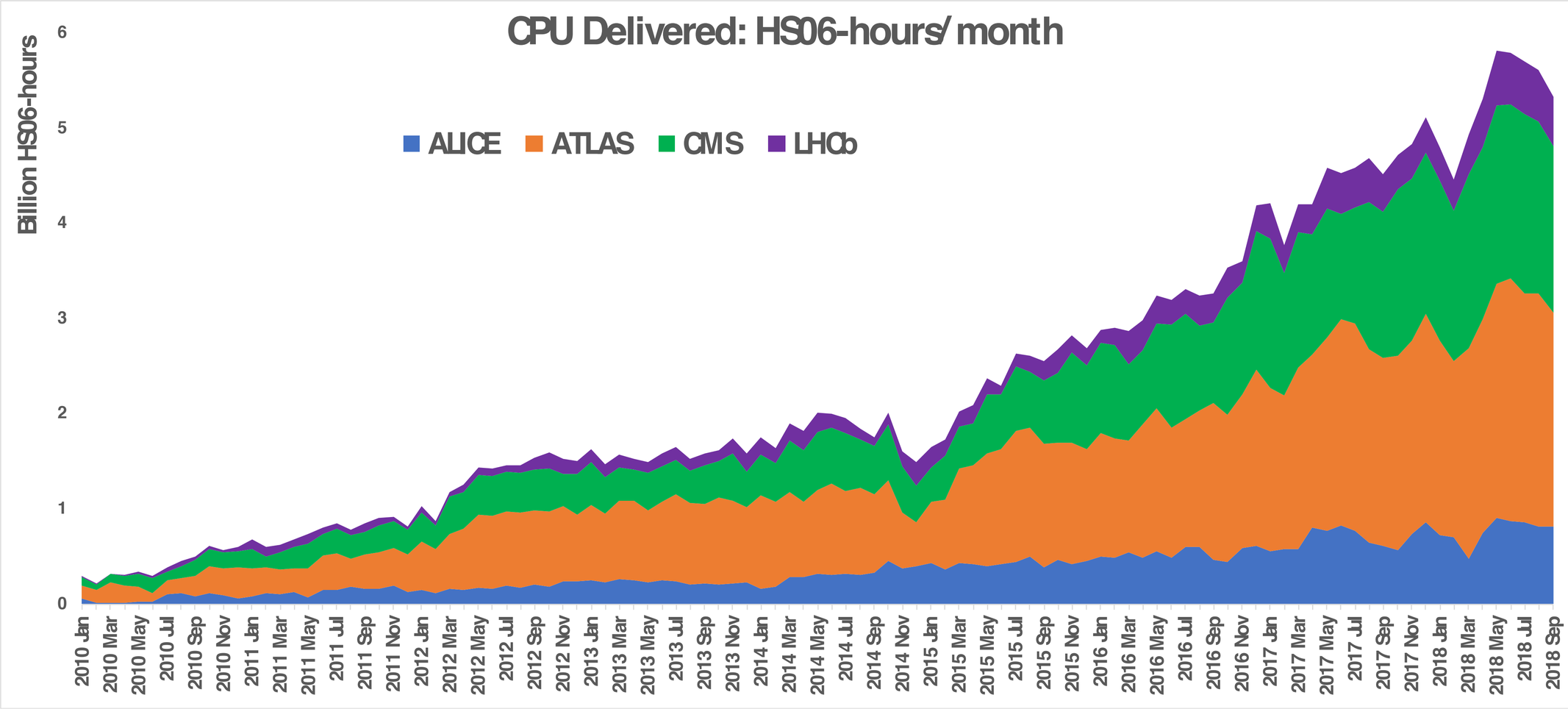
- High throughput computing
  - inventory >0.5 exabyte
- Extensive simulations
  - cross section calculation
  - particle tracking (Geant)
  - machine learning

WLCG

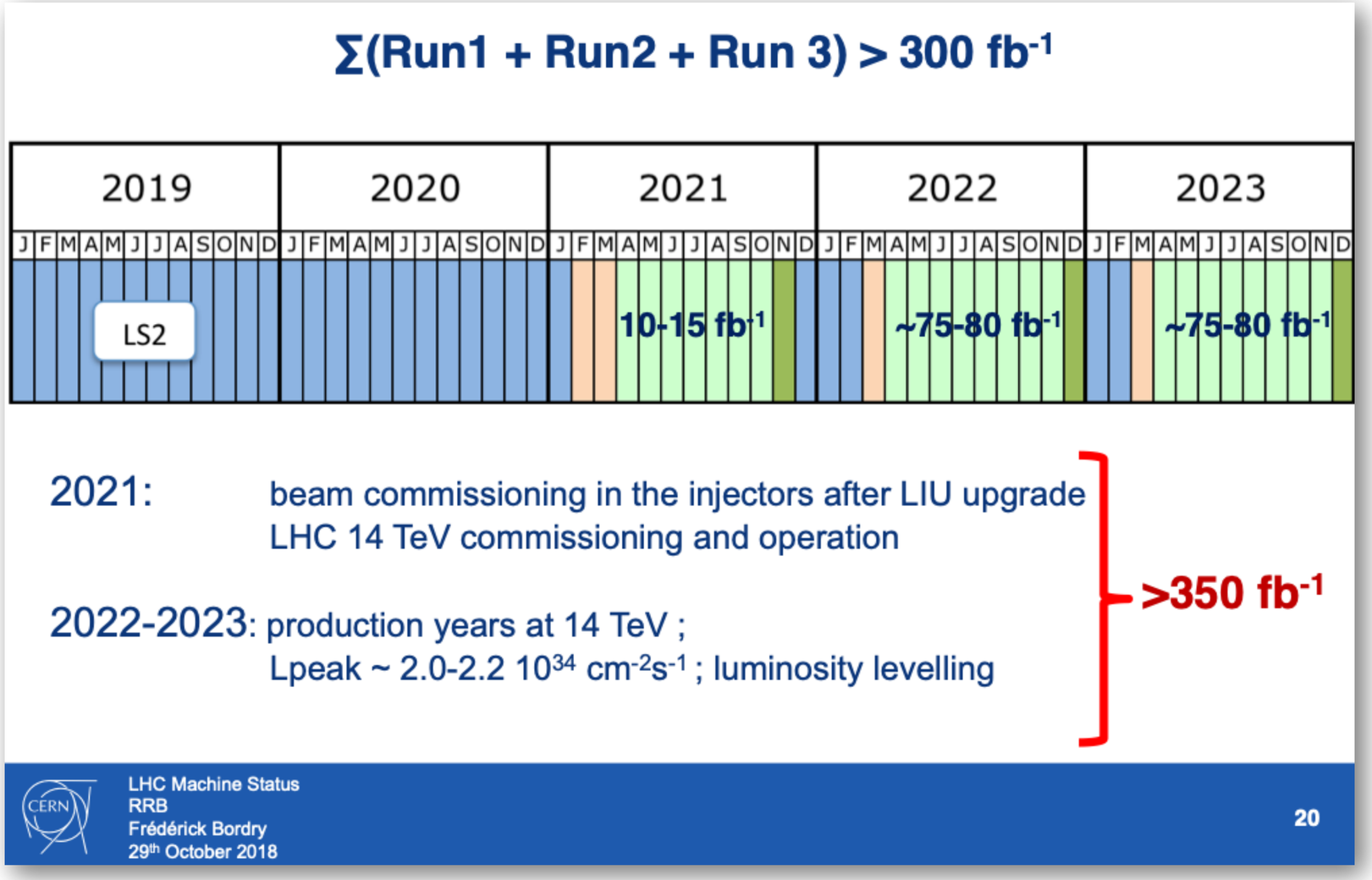




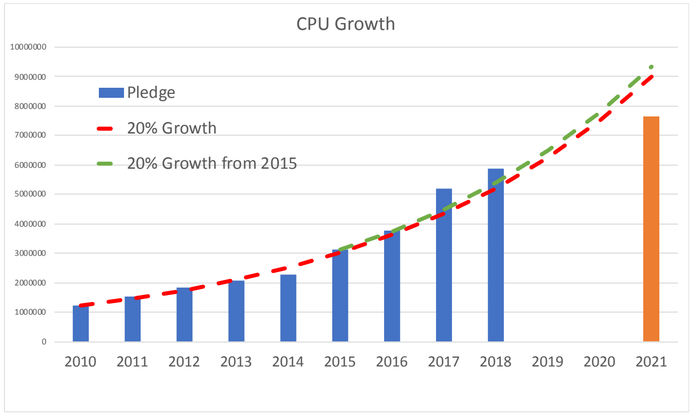
CPU delivered

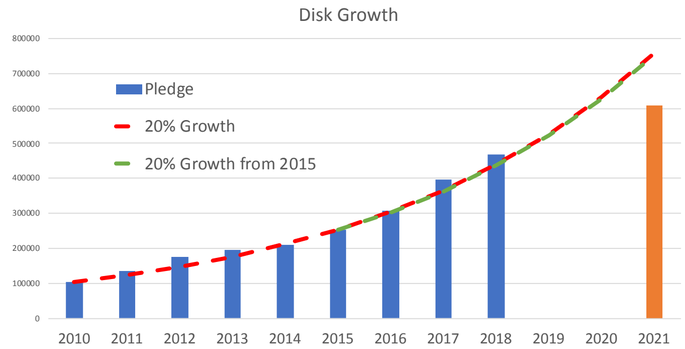


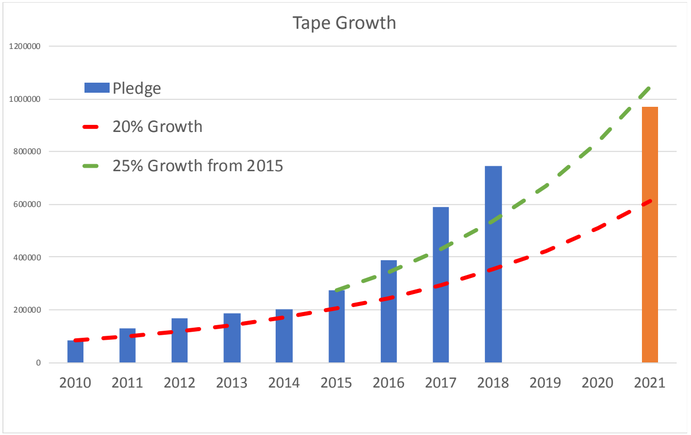
Run 3 Outlook – imminent future



Estimated Resource Evolution in Run 3







CPU

Disk

Tape

Considerable Uncertainties in Requirements

Evolution of WLCG

- Community White Paper
  - https://arxiv.org/abs/1712.06982
- WLCG
  - Strategy
- Funding Agency Strategies

Broad approach to Scientific Computing – Example ESCAPE

ESFRI Science Projects

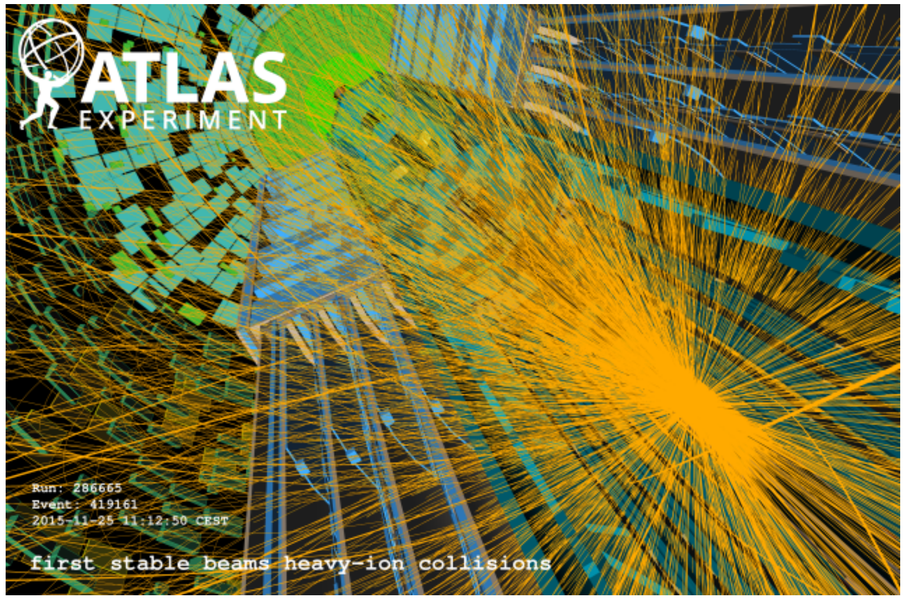
- HL-LHC
- FAIR
- KM3Net
- ELT
- EURO-VO
- SKA
- CTA
- JIVE-ERIC
- EST
- EGO-VIRGO
- (LSST)
- (CERN, ESO)

ESCAPE
European Science Cluster of Astronomy & Particle physics
ESFRI research infrastructures

Goals:
Prototype an infrastructure for the EOSC that is adapted to the Exabyte-scale needs of the large ESFRI science projects.
Ensure that the science communities drive the development of the EOSC.
Address FAIR data management, long term preservation, open access, open science, and contribute to the EOSC catalogue of services.

Examples of Computing Challenges in HEP

- Cross sections
  - a priori derived from quantum states
  - Lattice QCD
- Combinatorial searches
  - sequential searches extremely inefficient
- Pattern Recognition



Pattern Recognition

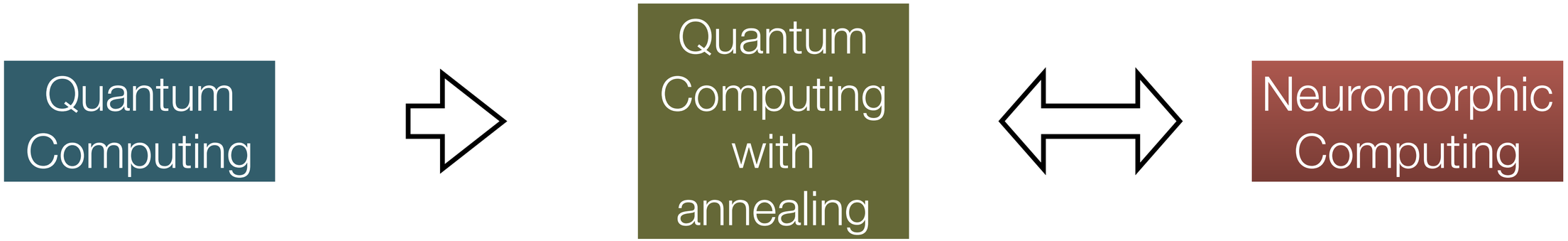
- Neural networks
  - Machine Learning
- Robustness in the presence of defects?
- Neuromorphic Computing
  - architectures derived from the human brain
  - electronics circuits becoming available
- Quantum Computing

well established

evolving…

today…

Quantum Computing and Neuromorphic Computing



Quantum Computing

- Some problems readily adapted to Quantum Computing
  - encryption
  - classification
  - minimisation
  - …
- Other problems require entirely new algorithms to be addressable by Quantum Computers

CERN openlab Research Interests

- Get access to emulators and simulators to start assessing development tools and methodology, develop proof-of-concept algorithms for HEP workloads
- Get access to real devices, benchmark, compare results
- Investigate and collaborate in the development of APIs and user interfaces to access QC systems
- Collaborate on engineering aspects of QC installation, primarily cryogenics
- Understand the role that CERN can have as part of broader QC capabilities development initiatives

Objectives of this meeting

- understand the level of interest of HEP and other scientific communities
- assess the state-of-the-art of research and industry
- bring different ideas and proposals together and
- plan ahead for joint research projects between science and industry within the CERN openlab Framework

Stimulus and Caution

- Quantum Computing offers to (re-)think algorithms in a fundamental way
  - Quantum Computers start to be available
  - a breakthrough in the number of qubits could emerge any time
- Yet, even when being very optimistic , Quantum Computing will not be the solution to all the needs in scientific computing
  - Storage and Data preservation

Have a fruitful workshop