HPC for Particle Physics and Astrophysics

EuroHPC Workshop

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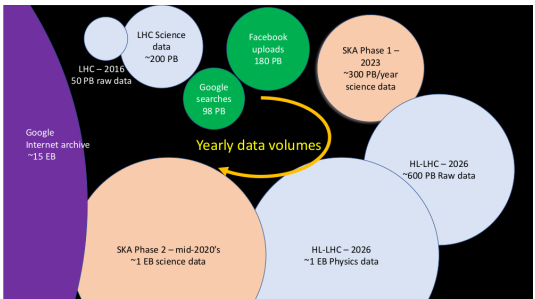
Introduction

- particle and astroparticle physics experiments collect, store, and process huge amount of data [1]
- the amount of data will be increasing with evolution/development of their experimental setup
- even though each experiment has some amount of pledged resources on grid sites, the available resources are insufficient
- search outside of traditional grid sites has started several years ago - some experiments are now able to use HPCs and clouds

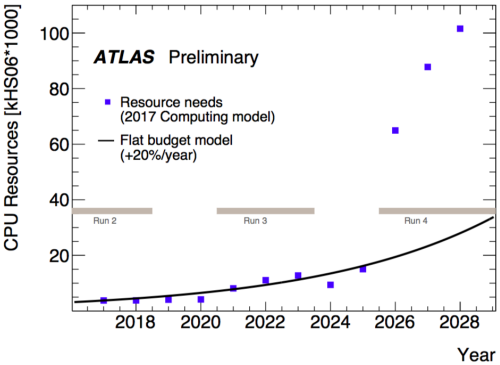


Current grid infrastructure

- Worldwide LHC Computing grid (WLCG) [2] project is a global collaboration of more than 170 computing centres in 42 countries, linking up national and international grid infrastructures providing global computing resources to store, distribute and analyse generated by the Large Hadron Collider (LHC) at CERN
- WLCG provide 750k cores for LHC experiments

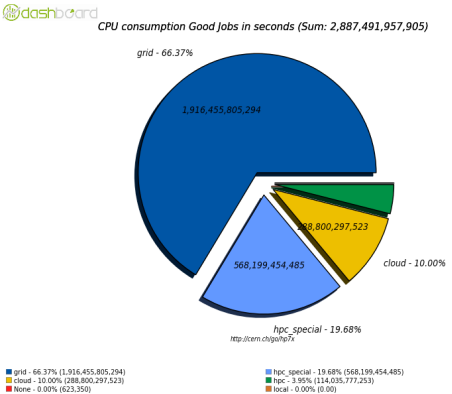
Computing requirements: ATLAS

- ATLAS is elementary particle physics experiment; amongst its discoveries is e.g Higgs boson (Nobel price 2013)
- required resources increase significantly with each run [3]
- ATLAS experiment does not have enough pledged resources (if flat budged scenario is expected) to fulfil its physics programme $\rightarrow$ usage of HPCs and clouds in opportunistic mode started several years ago



HPCs in ATLAS

- HPCs
  from many countries (China, Czech Republic, France, Germany, Norway, Russia, Sweden, Switzerland and United States) are used by ATLAS [4]
- HPCs provide significant number of additional cores [5]
- opportunistic usage (e.g. backfill) as well as through allocations
- ATLAS workflows:
  - many have high I/O
  - many run on single core
  - only specific workflow is used on HPCs (multicore with low I/O)



CPU consumption of resources available to ATLAS - January to April 2018

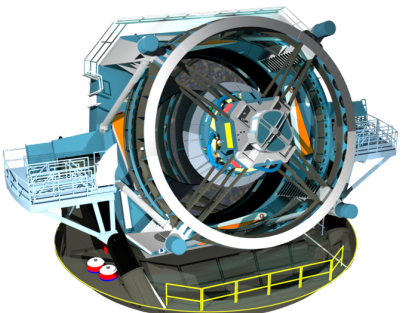
Computing requirements: astroparticle physics (Auger,CTA,LSST,SKA)

LSST

- wide-field
  survey reflecting telescope currently under construction (full operations for a ten-year survey is planned to start in January 2022)
- it will photograph the entire available sky
- it will collect 50 PB/year [1]

Auger

- it performs study of high-energy cosmic rays



Rendering of completed LSST [6]

Computing requirements: astroparticle physics (Auger,CTA,LSST,SKA)

SKA

- the next generation of radio telescope, currently under construction (with early science planned for 2020)
- it will detect radio waves from objects in space
- it will collect 300 PB/year [1]

CTA

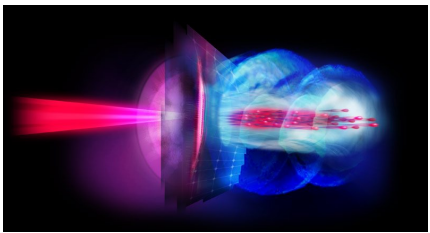
- the next generation ground-based observatory for gamma-ray astronomy at very-high energies

SKA (Artists Impressions) [7]

Computing requirements: ELI

ELI [8] (Extreme Light Infrastructure)

- 3 pillars, 1 pillar ELI - Beamlines in CZ
- will evolve into ERIC
  (European Research Infrastructure Consortium)
- HPC requirements in past:
  - PIC (Particle
    in Cell) - 1000s of cores for 3D simulations
  - IT4I used, no local cluster available
- Future requirements not precise enough
  (different groups of users will use ELI facilities)
- Predicted data volumes upto tens of PB/year
  (when all beamlines are used)



Computing requirements: CEICO

CEICO
[9](Central European Institute for Cosmology and Fundamental Physics)

- currently one cluster from CoGraDS
  (Cosmology, Gravity, and the Dark Sector of the Universe) project
- update planned for 2021
  - about 1000 CPU cores plus several GPU nodes with 8 GPUs each
  - usage of GPUs
  - simulation of early universe and other cosmological problems
  - low number of users ($<$ 15, 3 - 4 heavy users)
  - moderate disk space requirements (about 200 TB)
  - good scaling
    of the simulations, interested in usage of future large HPC facilities

Summary

- amount of data of several experiments in particle physics and astrophysics is expected to reach exabyte scale during the next decade
- resources beyond standard grid sites are needed
- HPCs and clouds are important non-traditional resources

References

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