Towards a Computing Model for the LHCb Run 3 Upgrade

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• Run 3 is the big step in the upgrade programme of the LHCb detector
  • Introducing major changes in sub-detectors, trigger and computing model
  • In comparison the upgrade to Run 4 (HL-LHC) will feature only minor changes

New in Run 2:

- Split High Level Trigger with final detector alignment and calibration
  - Offline quality reco in the HLT
  - Fully reco’ed smaller “Turbo” physics objects containing only necessary info

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Processing Workflow: Run 3 (2021 – 2023)

30 MHz inelastic event rate (full rate event building)
Software High Level Trigger
Full event reconstruction, inclusive and exclusive kinematic/geometric selections
Buffer events to disk, perform online detector calibration and alignment
Add offline precision particle identification and track quality information to selections
Output full event information for inclusive triggers, trigger candidates and related primary vertices for exclusive triggers

2-10 GB/s to storage

Changes in Run 3:
- Increase of luminosity and mu (x5) → Increase in offline simulation needs
- Remove HW trigger → Increase (x2) of trigger efficiency
- Vast majority of events in Turbo mode → Big increase in amount of collected signal information

“Turbo Workflow”

LHCb Trigger

Today

Run 3

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Monte Carlo Simulation

• Usage of grid resources for simulation will grow from ~ 80 % to ~ 90 %
• Despite pileup increase the workflow will stay same as Run 2
  • First step, no input data, w/ generator and detector response (95 % of work)
  • Second step with digitization and reconstruction
  • Optionally event filtering can be applied
→ 1st step of simulation can be easily deployed on all resources

• Simulation currently being moved to multi-threaded framework → reduction in memory usage opens new resource usage scenarios
Fast Monte Carlo

- CPU simulation needs scale with recorded integrated luminosity
  - Continuing with full simulation only not possible
- Working on fast Monte Carlo to keep resource needs under control
  - Several options already in production: ReDecay, RICHless, TrackerOnly, particleGun providing in general speedups between factor 5 and 10
  - More fast simulation workflows in preparation: Calo shower libraries and full parametric simulation based on Delphes,
Data Processing & User Analysis

• Classic offline data reconstruction and stripping (streaming / skimming / slimming) reduced to bare minimum

• Main data processing workflow is turbo processing
  • i.e. convert online (LHCb specific) to offline (ROOT) format and streaming
  • In Run 2 this turbo workflow accounts for 0.1 % of the grid work

• User analysis will move from individual to centrally organized data selections
  • Possibility to increase I/O by aggregating multiple selections (train model)
Storage Requirements

• Storage needs are driven by data of HLT output bandwidth
  • Tape needs incompressible, while mitigations possible for disk
    • E.g. parking scenarios are considered but introduce additional operational costs for the experiment and infrastructure costs for sites
• MC simulation output data format mostly migrated to m(icro)DST format with small contribution to needs introducing a size reduction of factor 20

• LHCb relies on a small amount of sites with disk storage:
  • T0 + 7 T1s + 13 T2s with minimum size requirements especially for T2s
  • Data caching especially on ”small disk sites” is not a major use case
Data Movement

- Introduce multiple streaming layers to keep data set size under control
  - O(10) streams from Online, O(100) streams Offline
  - Expect on average 500 TB per data set / data taking year
  - In case of parking these need to be staged in due time, O(days)

- Throughput to/from tape systems will increase by several factors

- WLCG/DOMA initiative welcome to possibly further reduce costs
  - Especially optimizations on the timescale of Run 3

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Resource Needs Based on Computing Model

• Basic assumptions are
  • 10 GB/s HLT output bandwidth with almost all data in Turbo stream
  • Run 2 simulation ramping down between 2021 and 2023
  • Percentage of fast and parametric simulated events gradually increasing
  • Most simulation output data in mDST format
  • ”Commissioning year” in 2021, full data taking in 2022, 2023
• Resource needs on average above extrapolations for the Run 3 years
• Working on additional scenarios with more mitigation measures
Summary

• LHC Run 3 is the major change of the LHCb upgrade programme
  • Resulting in a step up in offline resource needs for the experiment

• Several mitigation measures to keep resources under control are in place / under development
  • Turbo stream, fast simulation, mDST format, central analysis

• A computing model document will be submitted to the LHCC by the end of this year
Thank you for your attention !!!

[3] S. Ponce et al., The core software framework for the LHCb upgrade
[5] B. Siddi and A. Davis, A fully parametric option in the LHCb simulation framework
[7] F. Stagni, LHCb and DIRAC strategy towards the LHCb upgrade