



Operation of the ALICE Hyperloop analysis train system



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for the ALICE Collaboration

Seminar: The use of new methods for processing data of a physical experiment. Application of machine learning methods on the NICA complex. 28–29 Aug 2023, St. Petersburg, Nevsky 1

Outline

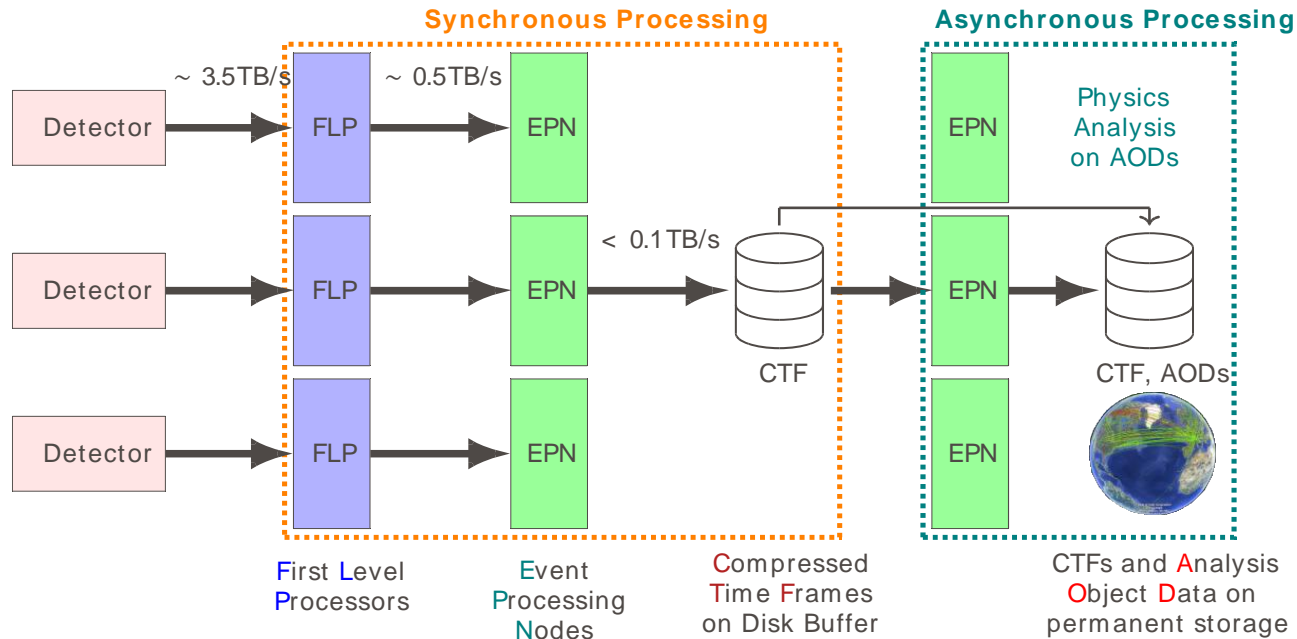


- WLCG infrastructure and AliEn framework in Run 3
- O2 Analysis Framework
- Hyperloop wagons and trains
- Comparison with LEGO trains
- Type of wagons: Service wagons and user analysis wagons
- Hyperloop web application
- Automatized wagon test with and train test / submission
- Bookkeeping and preservation
- Operation experience of the Hyperloop system
- Current status of the analysis in Run 3



ALICE

LHC Run 3 challenges of Data Processing



1 month of Pb–Pb data would produce several PB of final AO2Ds



ALICE

WLCG infrastructure and AliEn framework

- JAliEn Middleware

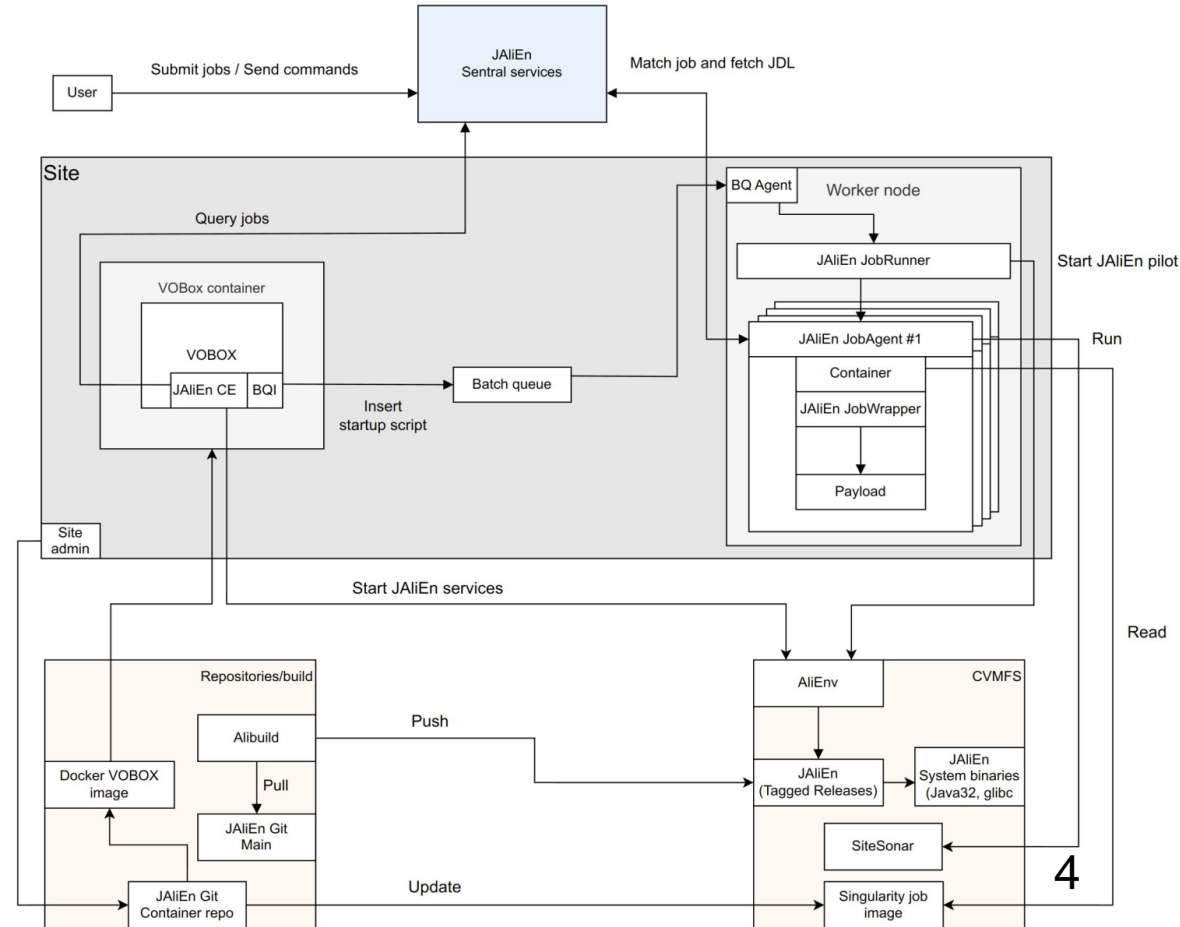
Grid Framework - combination of a Web Service and Distributed Agent Model. Data storage and job management.

- CVMFS central repository

ALICE analysis and required supplementary software delivery to run in Grid sites in containers. Integrated with build system for continuous deployment.

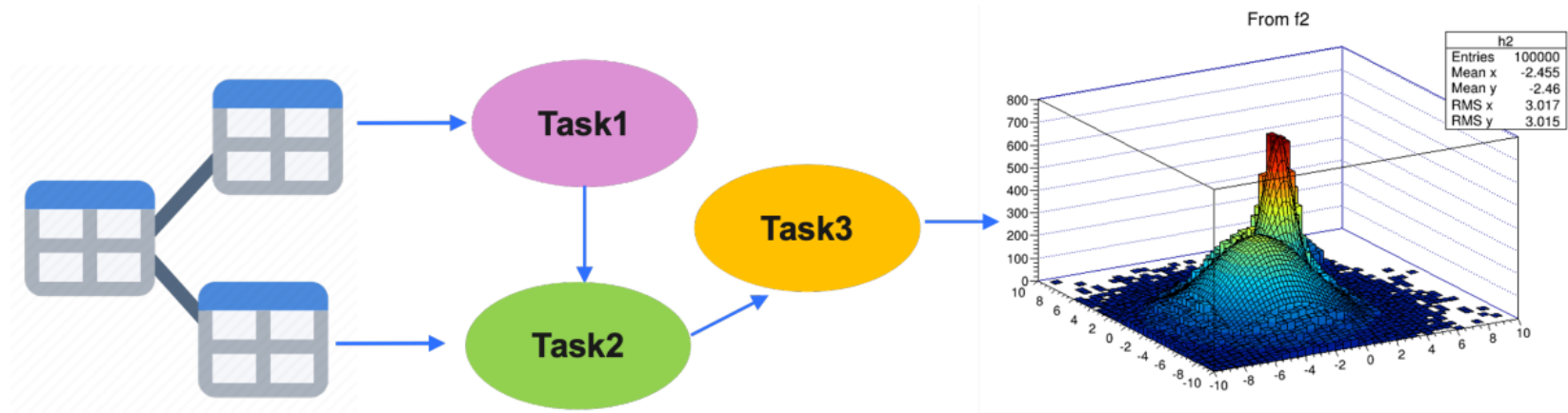
- Analysis software:

- User
- Centralized (Trains)
- Data and MC production



O2 Analysis Framework

- General structure of Data processing



Data Model

Analysis Tasks

ROOT serialized output

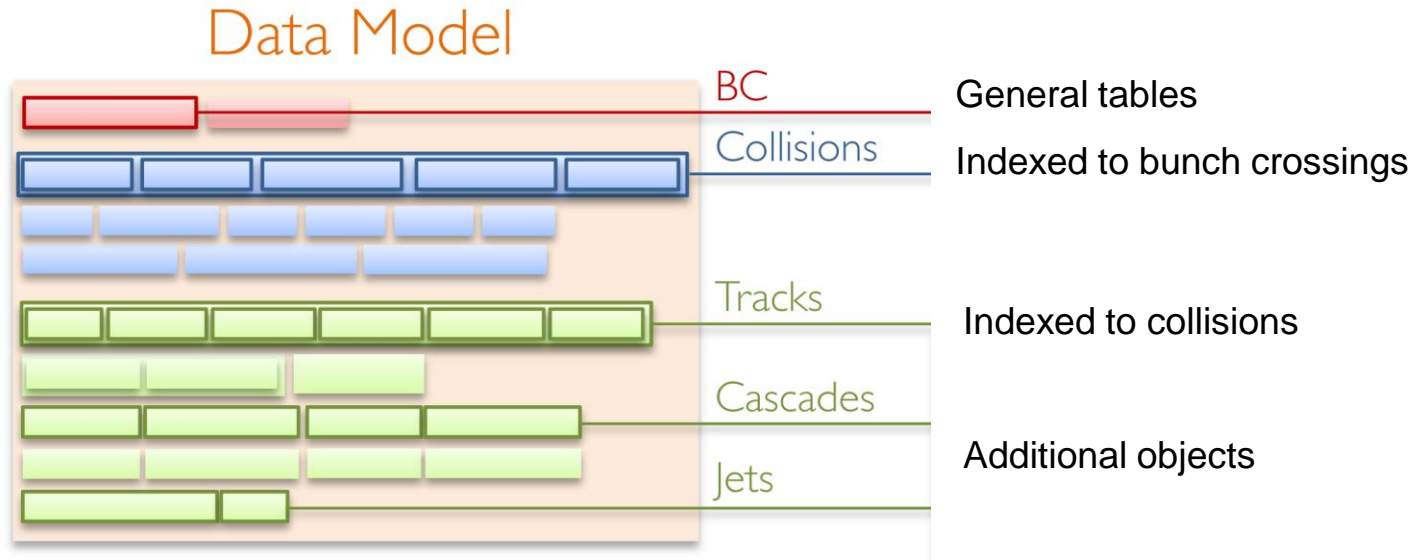
Interconnected tables
Based on Apache Arrows

User Tasks
workflows~wagons

AnalysisResults.root
+AO2Ds (derived data)

O2 Analysis Data Model

Apache Arrow Tables



Each analysis task is an executable → All the required are run in command line with pipe “|”

Plenty of Helper tasks → Produce required data tables on the fly

O2 Analysis Model: Types of Wagons



User wagons:

Spectra
Correlations
etc.

Core Service wagons: helpers,
dependencies of user wagons:

Centrality
Event Selection
Multiplicity
Timestamp Creator
Track Propagation
etc.

Wagon – analyzer

Creates and stores user defined analysis histograms

Wagon – producer

Mostly intended for generation of the derived data, which is used by other wagon or saved into AO2D files

Wagon – reader

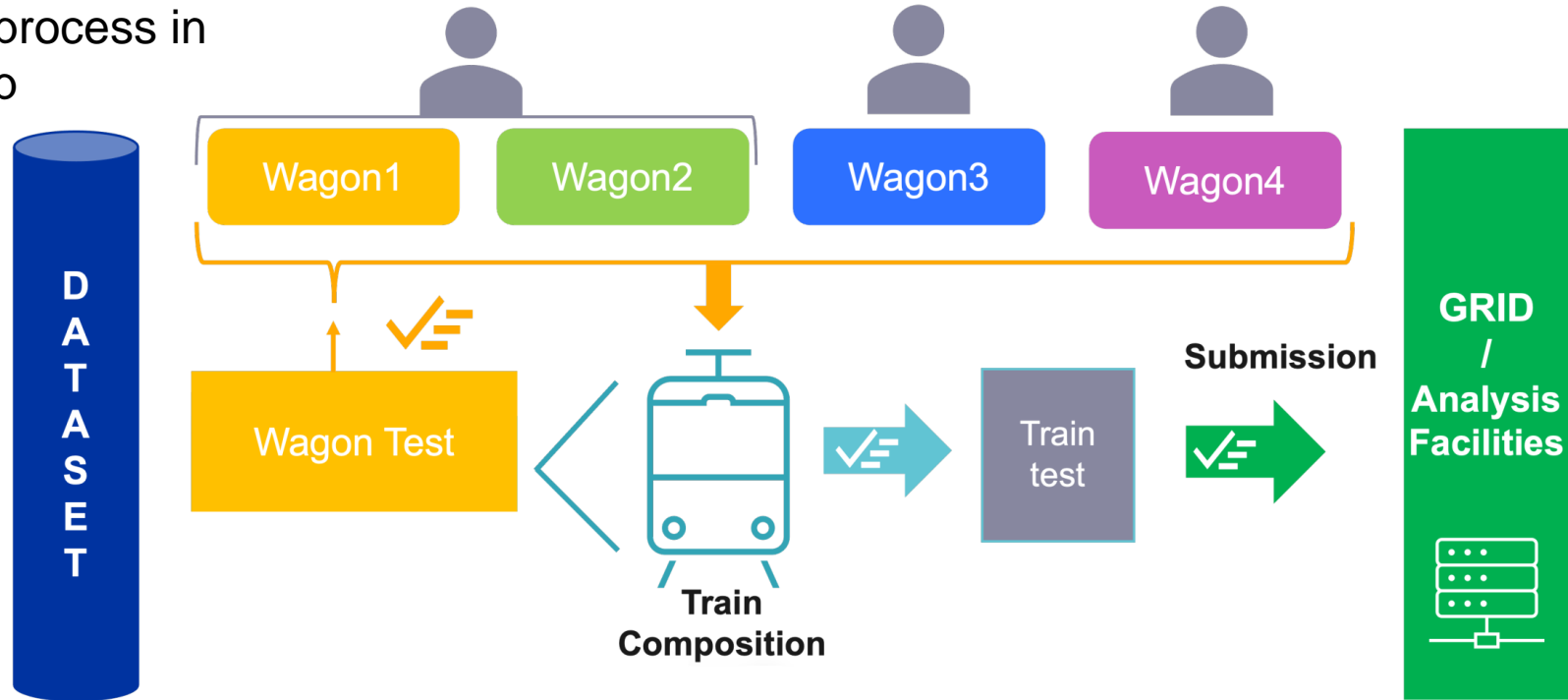
Analysis of the derived data

Wagon with parent level access



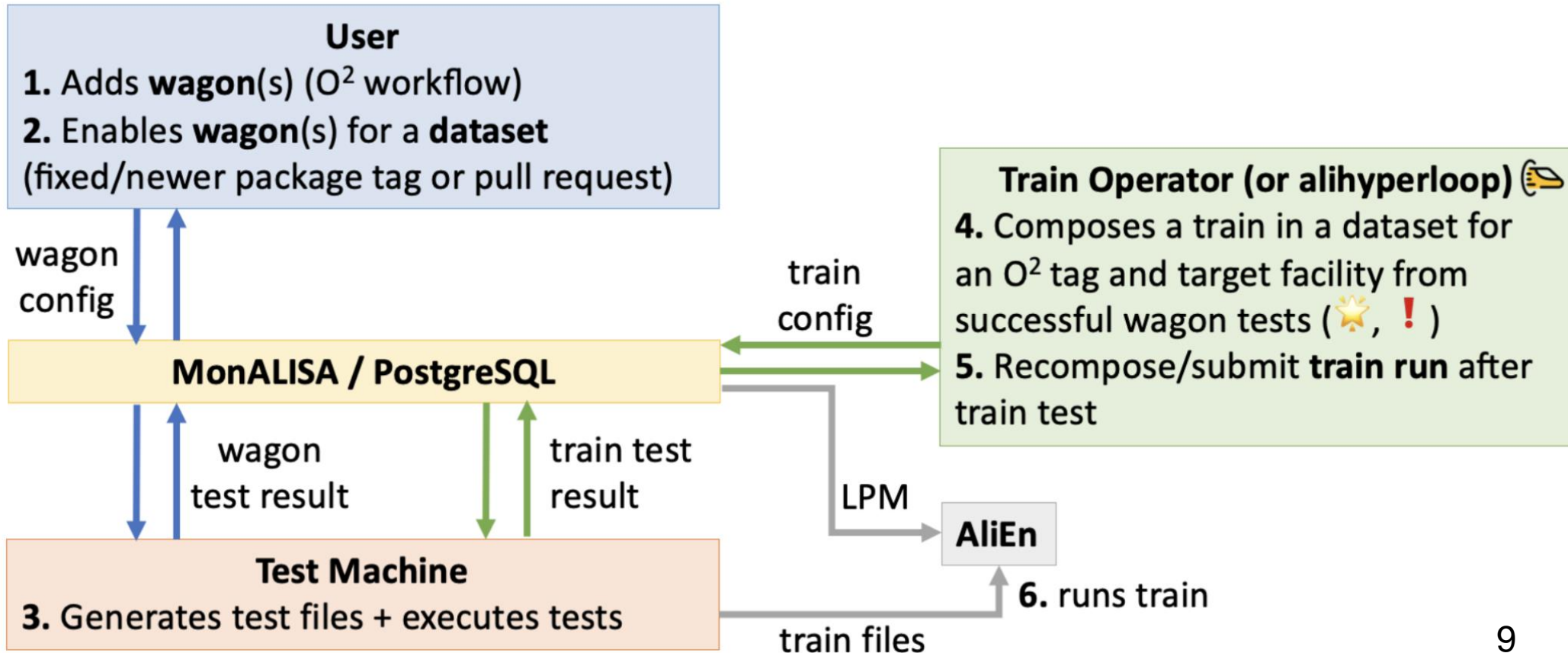
Hyperloop trains

Analysis process in Hyperloop



Config of each wagon is saved and stored in JSON file
Configs of all wagons are merged into general train's config

Process to submit hyperloop train



Comparison of Hyperloop trains and LEGO trains (Run 2)



ALICE LEGO train

- Analysis train framework for Run 2
- Analysis code is contained in an AliEn package, AliPhysics, and delivered via CVMFS
- Trains are defined per Physics Working Group (PWG), data type and collision system (~100)
- Analysis tasks (wagons) using the same dataset are run together
- Requires train operators (per PWG) to test, compose and submit train runs
- Main workhorse for Run 2 analysis:
 - 2020: 16 000 trains, 172 million Grid jobs



ALICE Hyperloop

- Analysis train framework for Run 3
- Analysis code is built into O2Physics available on CVMFS
- Advanced web-interface (frontend: React.js)
- Unified trains throughout PWGs
- Personalized user and operator interfaces
- Immediate and automatic wagon test
- Automatic train submission under certain defined conditions
- Wagon and dataset bookkeeping
- Usage Last year 2023: ~ 9000 trains, 24 million Grid jobs

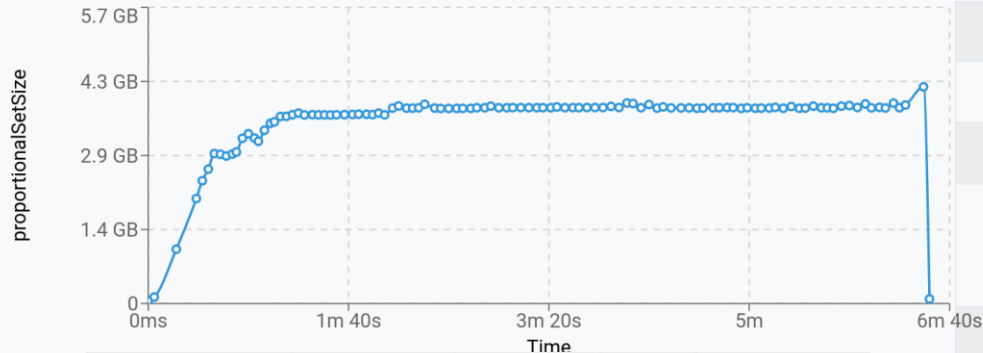
Wagon and train run test performance results



Train run 117133

General Test Submitted jobs Grid Statistics Wagon resources Merged Output Clone

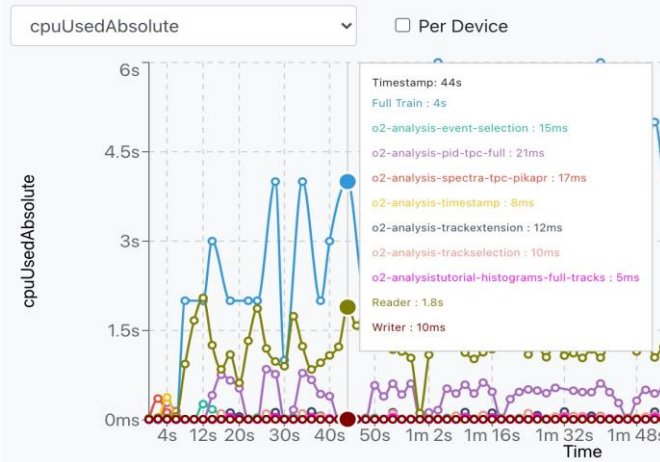
Full Test Per Wagon Graphs



Wagon	PSS Memory	Private Memory	CPU Time	CCDB	
				Calls	Transfer size
Reader	Max: 1.6 GB Avg: 1.2 GB Slope: 3.9 MB/s	1.1 GB 794.8 MB 1.8 MB/s	1m 51s		
EventSelection	Max: 308.7 MB Avg: 150.4 MB Slope: -360.1 KB/s	120.5 MB 114.7 MB 179.5 KB/s	3s		
HistogramsFull	Max: 25.7 MB Avg: 19.6 MB Slope: 87.7 KB/s	9.6 MB 9.5 MB 157.4 B/s	2s		
PIDTPCFull	Max: 226.3 MB Avg: 185.5 MB Slope: 368.5 KB/s	158.3 MB 120.2 MB 11.7 KB/s	38s		

Number of input files	4
Input size	7.0 GB
Output size	4.8 MB
PSS Memory	Max: 3.9 GB Avg: 3.6 GB Slope: 2.4 MB/s
Private Memory	Max: 3.4 GB Avg: 3.2 GB Slope: 1.2 MB/s
Timing	CPU: 9m 57s Wall: 6m 29s
Throughput	9.2 MB/s/core
Expected resources	19h 49m

Per wagon:



Datasets



Latest change by **rcruceru** at **02 June 2023 at 10:20:45 GMT+3**



LHC22f_pass4 (DATA)

<https://alice.its.cern.ch/jira/browse/O2-3790>

Options [Learn more](#)

- Activated
- Run final merging over all runs in this dataset
- Dataset sampling

Linked Datasets:

Analysis Facility Staging [Learn more](#)

Dataset size: 661.7 GB

File Pattern:

Dataset size varies from few GB to several PB

Not staged

History (bookkeeping)

- Dataset is **updated** by **rcruceru** [02 June 2023 at 10:20:45 GMT+3](#)
- Dataset (production) is **created** by **rcruceru** [02 June 2023 at 10:20:09 GMT+3](#)
- Dataset production LHC22f_apass4 is **created**
- Mergelist all of LHC22f_apass4 production is **created**
- Dataset is **created** by **rcruceru** [02 June 2023 at 10:19:51 GMT+3](#)

Automatic Train Composition [Learn more](#)

Automatic train composition: Scheduled

Maximal CPU time in days: 550

Maximal trains per analysis per week: 14

- Composition schedule (CET):
- | | | | | | | |
|------------------|----------------|-----------------|------------------|-------------------|-------------------|------------------|
| Monday - 03:00 | Monday - 15:00 | Tuesday - 03:00 | Tuesday - 15:00 | Wednesday - 03:00 | Wednesday - 15:00 | Thursday - 03:00 |
| Thursday - 15:00 | Friday - 03:00 | Friday - 15:00 | Saturday - 03:00 | Saturday - 15:00 | Sunday - 03:00 | Sunday - 15:00 |

Bookkeeping

Wagon changelog

Correlations

Analysis: Hyperloop Framework Test Analysis
Workflow: o2-analysis-cf-correlations
Dependencies: Core Service Wagons/Centrality_Run2,Core Service Wagons/EventSelection_Run2,Core Service Wagons/TrackSelection_Run2
Max DF size: 100000000
Max derived file size: 0

[Compare](#) [Unselect All](#)

- Wagon is **updated** by *jpgrosseo* [14 December 2022 at 10:30:27 CET](#)
- Wagon (configuration) is **updated** by *jpgrosseo* [14 December 2022 at 10:30:27 CET](#)
- Configuration **correlation-task/axisDeltaEta** of **base** subwagon is **updated** by *jpgrosseo*
- Wagon is **updated** by *jpgrosseo* [12 December 2022 at 11:40:59 CET](#)
- Wagon (configuration) is **updated** by *jpgrosseo* [12 December 2022 at 11:40:59 CET](#)
- Configuration **correlation-task/cfgNoMixedEvents** of **base** subwagon is **updated** by *jpgrosseo*
 - Type**
Int
 - Value** (\emptyset - inherited from base)
- 5
+ 4
 - Help**
Number of mixed events per event
 - Default**
5

Bookkeeping

Wagon comparison at different timestamps

CorrelationsFilteredOnTheFly at 21 September 2022 at 08:57:51 CEST vs at 24 September 2021 at 08:39:18 CEST

Wagon settings Configuration Derived data

(∅ - inherited from base) base

correlation-hash-task

processAOD 0

processDerived 1

correlation-task

axisDeltaEta Bins: 40, Min: -2, Max: 2

axisDeltaPhi Bins: 72, Min: -1.5707963705062866, Max: 4.71238899230957
Bins: 72, Min: -1.5707963267948966, Max: 4.71238898038469

axisEtaEfficiency Bins: 20, Min: -1, Max: 1

axisMultiplicity Variable width: 0,5,10,20,30,40,50,100,1,2000
Variable width: 0,5,10,20,30,40,50,100,1

axisPtAssoc Variable width: 0,5,1,1,5,2,3,4,6

Bookkeeping



Train comparison

My Analyses All Analyses Dashboard AliHyperloop Train Submission Train Runs Datasets DPG Runlists ?

Train Runs

Trains with issues

Train	Wagons	Operator	Package	Dataset	Composed	Train status	Test
18296	Correlations, SpectraTPCPiKP + 7 others	alhyperloop	O2Physics::nightly-20220111-1	LHC15o_dev	11/01/22, 06:01	Done	👍
18295	HistogramsFull, SpectraTPCTiny + 4 others	alhyperloop	O2Physics::nightly-20220111-1	LHC15o_dev	11/01/22, 06:01	Done	👍
18289	TrackPropagation, TrackPropagationConsumer	alhyperloop	O2Physics::nightly-20220110-1	PilotMC_LHC21i1_nightly	11/01/22, 00:01	Done	👍
18286	alice3-trackextension, hf-candidate-creator-2prong-openhf + 7 others	alhyperloop	O2Physics::nightly-20220110-1	LHC21d9l_pp	10/01/22, 18:01	Done	👍
18279	HistogramsFull2, E4 others						👍
18278	HistogramsFull						👍
18271	alice3-trackextens2prong-openhf +						👍
18269	alice3-trackextens2prong-openhf +						👍
18268	alice3-trackextens2prong-openhf +						👍
18264	HistogramsFull						👍
18263	Correlations, Spec						👍
18236	Correlations, Spec						👍

Train run 18296 vs 18295

Package tag O2Physics::nightly-20220111-1

Dataset LHC15o_dev

Operator alhyperloop

Created 11 January 2022, 06:01:05 11 January 2022, 06:01:04

Settings slow train derived data automatic submission

Train run 18296	Common	Train run 18295
Correlations	TimestampCreator	HistogramsFull
SpectraTPCPiKP	TrackExtension_Run2	SpectraTPCTiny
Centrality_Run2	TrackSelection_Run2	PIDTPC
EventSelection_Run2		
Multiplicity_Run2		
PIDTPCFull		

Test status Done (test output) Done (test output)

Target Grid - Single core

Train status Done

Train duration 2h 29m 26.9s 4h 52m 44.6s

Roles of Analyzer and Operator



ANALYZER



My Analyses

All Analyses

Dashboard

- Creates and configure wagons
- Runs wagon tests
- Studies test results
- Makes use of automatic train composition or ask to compose train
- Studies the resource consumption
- Stores derived data to be used in subsequent trains
- Makes use of history and statistics views

OPERATOR



Train Submission

Train Runs

Datasets

Derived Data

DPG runlists

Trains with issues

- Runs the system on a daily 24/5 basis
- Ensures efficient usage of the resources
- Follows up on overall system status
- Investigates issues and delegate to experts
- Responds to user requests
- Submits trains to the Grid or AFs
- Manages datasets
- Creates datasets of the derived data

- PWG Convener: approves long trains (> 200 Tb)

Current status



- Hyperloop is in production since early 2022.
- Run 3 data and MC are available for the analysis.
- All Run 2 data and considerable amount of MC data converted to AO2D format and available on Hyperloop
- Operator support on a daily 24/5 basis by four institutional clusters in different timezones
- ~300 datasets available (including derived data)
- ~300 users of hyperloop system
- More than 100k wagon tests done, ~12000 trains run on Grid or AF
- The average completion time of the trains is between 7 and 14 hours

NISER	2:00-9:00 UTC
St. Petersburg	9:00-13:00 UTC
Brescia/Pavia	13:00-17:00 UTC
US cluster	17:00-1:00 UTC

Conclusion



- Hyperloop is a modern innovative analysis train system for ALICE LHC Run 3 and 4, replacing the LEGO Train system used in Run 1 and 2.
- It has been fully integrated with the O2 analysis framework to enable analysis on the exceptionally large data samples
- It enables fast deployment and run of user analysis allowing efficient share of the resources to run multiple workflows of many users on the Grid.
- It provides full archival of past configurations, changelogs and comparison tools.

Thank you

